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EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Pallet Payloads Interface Definition Document

International Space Station Program

March 8, 1999

Working Draft

National Aeronautics and Space Administration
International Space Station Program
Johnson Space Center
Houston, Texas
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INTERNATIONAL SPACE STATION
INTERFACE DEFINITION DOCUMENT

EXPEDITE THE PROCESSING OF EXPERIMENTS TO SPACE STATION (EXPRESS) PALLET PAYLOADS

WORKING DRAFT
MARCH 8, 1999

CONCURRENCE

PREPARED BY:	Ed Massey	2-8K39 (TBE)
	PRINTED NAME	ORGN
	SIGNATURE	DATE
CHECKED BY:	Brad McCall	2-8K3H
	PRINTED NAME	ORGN
	SIGNATURE	DATE
SUPERVISED BY (BOEING):	Dave Williams	2-8K3H
	PRINTED NAME	ORGN
	SIGNATURE	DATE
SUPERVISED BY (NASA):	Lowell Primm	JA62
	PRINTED NAME	ORGN
	SIGNATURE	DATE
DQA:	Nancy McMahon	2-8K39 (TBE)
	PRINTED NAME	ORGN
	SIGNATURE	DATE

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Boeing Defense & Space Group
Missiles & Space Division
(a division of The Boeing Company)
Huntsville, Alabama

PREPARED BY:	E. Massey	TBE	
CHECKED BY	R. Stallings	TBE	
APPROVED BY:	R. Stallings	TBE	
DQA:	N. McMahon	TBE	
QA:	Not Applicable	TBE	
SUPERVISED BY:	B. McCall	2-8K3H	
APPROVED BY:	D. Williams	2-8K3H	
	SIGNATURE	ORGN	DATE

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ABSTRACT

This Interface Definition Document (IDD) provides a single source of design and interface compliance requirements which must be satisfied in order to certify an EXPRESS Pallet (ExP) payload for integration onto an applicable ExP. The physical, functional, and environmental design requirements associated with payload safety and interface compatibility are included herein. This document complements the orbiter IDD, NSTS 21000-IDD-ISS, and forms the basis for the payload-specific Interface Control Documents (ICD). This document covers transportation and on-orbit phases of the ExP payloads. This document is submitted in accordance with Letter Contract NAS8-50000, Modification 266, and Data Requirement (DR) SE44.

The EXPRESS Pallet IDD, Working Draft, has been generated with the best data available and is provided as interface information to EXPRESS Pallet payloads. The data presented in this document is subject to change due to maturity issues. The Preliminary Design Review (PDR) for EXPRESS Pallet is pending. The Attached Payload Interface Requirements Document (IRD) is currently being generated. Detailed requirement definition for the Unpressurized Logistics Carrier (ULC) and Sidewall Carrier are under way.

Information without a firm traceable source is denoted as To Be Confirmed (TBC). TBC data is primarily dependent on the EXPRESS Pallet design and development process and is considered to be at risk. Therefore, EXPRESS Pallet payloads should use this data with caution. Items that are unknown are noted as To Be Determined (TBD). It is hoped that this document will be a useful tool in the design of EXPRESS Pallet payloads, and changes to the requirements documented herein will be minimal. Updates for TBC/TBD data will be provided in future updates of the IDD.

KEY WORDS

Design Requirements

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TABLE OF CONTENTS

SECTION		PAGE
	TITLE PAGE	iii
	ABSTRACT AND KEY WORDS	v
	DRR	vii
	TABLE OF CONTENTS	ix
1.	**INTRODUCTION**	**1-1**
1.1	PURPOSE	1-1
1.1.1	*Definition of IDD*	*1-1*
1.1.2	*Definition of Payload-Unique ICD*	*1-2*
1.1.3	*Definition of Flight-Unique ICA*	*1-2*
1.1.4	*Waivers, Deviations, and Exceedances*	*1-2*
1.2	SCOPE	1-3
1.3	EXP PAYLOAD ACCOMMODATIONS	1-4
1.3.1	*Precedence*	*1-4*
1.3.2	*Effectivity*	*1-4*
1.4	CHANGE POLICY	1-4
1.5	DOCUMENTATION TREE	1-6
1.6	TECHNICAL POINT OF CONTACT	1-6
2.	**DOCUMENTS**	**2-1**
2.1	INTRODUCTION	2-1
2.2	APPLICABLE DOCUMENTS	2-1
2.2.1	*Government Documents*	*2-1*
2.2.2	*Non-Government Documents*	*2-4*
2.3	REFERENCE DOCUMENTS	2-4
2.3.1	*Government Documents*	*2-4*
2.3.2	*Non-Government Documents*	*2-6*
2.4	BOEING NORTH AMERICAN (BNA) DRAWINGS AND SPECIFICATIONS	2-6
2.5	INSTITUTO NACIONAL DE PESQUISAS ESPACIASIS (INPE) DRAWINGS	2-6
3.	**PHYSICAL AND MECHANICAL INTERFACES**	**3-1**
3.1	GEOMETRIC RELATIONSHIPS	3-1
3.1.1	*Space Shuttle Orbiter Coordinate Systems*	*3-1*
3.1.2	*ISS Coodinate Systems*	*3-1*

TABLE OF CONTENTS (CONTINUED)

SECTION		PAGE
3.1.3	*ExP Coordinate Systems and Nomenclature*	*3-1*
3.1.4	*ULC Coordinate System*	*3-7*
3.1.5	*Sidewall Carrier Coordinate System*	*3-7*
3.2	DIMENSIONS AND TOLERANCES	3-7
3.3	MECHANICAL INTERFACES	3-14
3.3.1	*EXPRESS Pallet Adapter*	*3-14*
3.4	MECHANICAL PAYLOAD PROVISIONS	3-14
3.4.1	*Payload Mounting Provisions*	*3-14*
3.4.2	*Connector Panel Interfaces Provisions*	*3-14*
3.4.3	*Fasteners Requirements*	*3-21*
3.4.4	*Payload Mass and CG Capabilities*	*3-22*
3.5	GROUND SUPPORT EQUIPMENT (GSE)	3-23
3.5.1	*Ground Handling Requirements*	*3-23*
3.5.2	*Ground Handling Payload Attachments*	*3-23*
3.6	PAYLOAD ENVELOPE REQUIREMENTS	3-23
3.6.1	*Payload Static Envelopes*	*3-23*
3.6.2	*Sharp Edges and Corners*	*3-23*
4.	**STRUCTURAL INTERFACES**	**4-1**
4.1	INTRODUCTION	4-1
4.2	OPERATIONAL LOADS	4-1
4.2.1	*Component Frequency*	*4-1*
4.2.2	*Payload Low Frequency Launch and Landing Loads*	*4-1*
4.3	EMERGENCY LANDING LOAD FACTORS	4-3
4.4	RANDOM VIBRATION	4-3
4.5	EXP ADAPTER PLATE INTERFACE LOADS	4-3
4.6	ON-ORBIT LOADS	4-3
4.6.1	*Payload Berthing*	*4-5*
4.6.2	*Reboost*	*4-5*
4.6.3	*Payload-Induced Operational Loads*	*4-5*
4.6.4	*Thermal Effects*	*4-5*
4.6.5	*External Induced Loads*	*4-5*
4.7	EXP PAYLOAD STRUCTURAL DESIGN	4-6
4.7.1	*Structural Design*	*4-6*
4.7.2	*Fracture Control*	*4-8*
4.8	LIFT-OFF AND ASCENT ACOUSTICS	4-8

4.9 DEPRESSURIZATION/REPRESSURIZATION REQUIREMENTS 4-8

TABLE OF CONTENTS (CONTINUED)

SECTION		PAGE
4.10	GROUND HANDLING ENVIRONMENTS	4-8
4.10.1	*Ground Handling Load Factors*	*4-8*
4.10.2	*Ground Handling Shock Criteria*	*4-9*
4.11	MICROGRAVITY DISTURBANCES	4-10
4.11.1	*Quiescent Period Payload-Induced Quasi-Steady Accelerations*	*4-10*
4.11.2	*Quiescent Period Payload-Induced Transient Accelerations*	*4-10*
4.11.3	*On-Orbit Vibration - Quiescent Periods*	*4-10*
5.	**THERMAL INTERFACE**	**5-1**
5.1	INTRODUCTION	5-1
5.2	EXP THERMAL CONTROL	5-1
5.2.1	*Thermal Control*	*5-1*
5.3	GENERAL REQUIREMENTS	5-1
5.3.1	*EVA Touch Temperatures*	*5-1*
5.3.2	*Payload Heat Conduction to ExPA*	*5-1*
5.3.3	*ISS Thermal Radiation Requirements*	*5-1*
5.3.4	*Attached Payload-Induced Thermal Effects*	*5-2*
5.3.5	*Mating Thermal Differential*	*5-2*
5.4	EXP THERMAL ENVIRONMENT DEFINITION	5-2
5.4.1	*Environmental Conditions*	*5-2*
5.4.2	*ExP-to-ExPA Interface Temperatures*	*5-3*
5.4.3	*ExP Thermal Radiation Environments*	*5-3*
5.5	ORBITER ENVIRONMENTAL CONTROL INTERFACES	5-3
5.5.1	*Purge and Vent of Cargo Bay*	*5-3*
5.5.2	*Trans Atlantic Landing (TAL) and Emergency Landing Site (ELS) Abort Contingency*	*5-3*
5.6	EXP PAYLOAD THERMAL CONTROL RECOMMENDATIONS AND TECHNICAL INFORMATION	5-4
5.7	ULC THERMAL CONTROL	5-4
5.8	SIDEWALL CARRIER THERMAL CONTROL	5-4
6.	**ELECTRICAL POWER INTERFACES**	**6-1**
6.1	INTRODUCTION	6-1
6.2	ELECTRICAL POWER INTERFACE DESCRIPTION	6-1
6.2.1	*On-Orbit/Stay-Alive Power Interface (ExPA Nominal Power Feeds)*	*6-1*
6.2.2	*Emergency Power Interface*	*6-1*

6.3 28-VDC OUTPUT CHARACTERISTICS (TBC) 6-1

TABLE OF CONTENTS (CONTINUED)

SECTION		PAGE
6.3.1	*28-Vdc Steady-State Voltage Range*	*6-4*
6.3.2	*28-Vdc Output Ripple Voltage Characteristic*	*6-4*
6.3.3	*28-Vdc Transient Voltage Characteristic*	*6-4*
6.3.4	*28-Vdc Source Impedance*	*6-4*
6.3.5	*28-Vdc Output Current*	*6-4*
6.3.6	*28-Vdc Output Electrical Isolation*	*6-5*
6.4	120-VDC OUTPUT CHARACTERISTICS	6-5
6.4.1	*120-Vdc Steady-State Voltage Range*	*6-6*
6.4.2	*120-Vdc Ripple Voltage Characteristic*	*6-6*
6.4.3	*120-Vdc Transient Voltage Characteristic*	*6-6*
6.4.4	*120-Vdc Source Impedance*	*6-6*
6.4.5	*120-Vdc Non-Normal Operation*	*6-11*
6.4.6	*120-Vdc Output Current*	*6-11*
6.4.7	*120-Vdc Output Mutual Isolation*	*6-14*
6.5	ALTERNATING CURRENT ISOLATION	6-14
6.6	PAYLOAD POWER ALLOCATION	6-14
7.	**ELECTROMAGNETIC COMPATIBILITY (EMC)**	**7-1**
7.1	CIRCUIT EMC CLASSIFICATIONS	7-1
7.2	SHUTTLE-PRODUCED INTERFERENCE ENVIRONMENT	7-1
7.2.1	*Conducted Interference - Shuttle/Cargo Bay*	*7-1*
7.2.2	*Radiated Interference - Shuttle/Cargo Bay*	*7-1*
7.3	PAYLOAD-PRODUCED INTERFERENCE ENVIRONMENT	7-3
7.3.1	*Payload-Produced Conducted Noise - Shuttle/Cargo Bay*	*7-3*
7.3.2	*Payload-Produced Radiated Fields - Shuttle/Cargo Bay*	*7-3*
7.4	ELECTROMAGNETIC COMPATIBILITY	7-4
7.4.1	*Emission and Susceptibility Limits and Test Methods*	*7-4*
7.4.2	*Electrostatic Discharge*	*7-11*
7.5	ELECTRICAL BONDING	7-12
7.5.1	*Electrical Bonding of Payload Hardware*	*7-12*
7.5.2	*Electrical Bonding of Payload Structures*	*7-13*
7.5.3	*Circuit Reference Symbols*	*7-13*
7.6	POWER CIRCUIT ISOLATION AND GROUNDING	7-14
7.6.1	*ExP 120-Vdc and 28-Vdc Primary Power Bus Isolation*	*7-14*
7.6.2	*Dc Power Ground Reference*	*7-14*
7.6.3	*Payload Secondary Power Isolation and Grounding*	*7-14*

7.6.4 GSE Isolation and Grounding 7-14

TABLE OF CONTENTS (CONTINUED)

SECTION		PAGE
7.7	SIGNAL ISOLATION AND GROUNDING REQUIREMENTS	7-16
7.7.1	*Ethernet*	*7-16*
7.7.2	*Analog*	*7-16*
7.7.3	*Discrete*	*7-16*
7.7.4	*Shield References*	*7-16*
8.	**ELECTRICAL POWER AND DATA WIRING INTERFACE**	**8-1**
8.1	GENERAL	8-1
8.2	CONNECTOR TYPES	8-1
8.3	CABLE DESIGN AND CONSTRUCTION	8-1
8.4	CABLE INSTALLATION AND ROUTING	8-1
8.5	WIRING DETAILS AND PIN ASSIGNMENTS (TBC)	8-1
9.	**COMMAND AND DATA HANDLING (C&DH) INTERFACES**	**9-1**
9.1	MIL-STD-1553B COMMUNICATIONS	9-1
9.1.1	*Signal Characteristics*	*9-1*
9.1.2	*Processing Requirements*	*9-2*
9.2	ETHERNET COMMUNICATIONS	9-2
9.2.1	*Signal Characteristics*	*9-2*
9.2.2	*Communications Protocol*	*9-2*
9.2.3	*Throughput Requirements*	*9-2*
9.3	ANALOG COMMUNICATIONS	9-2
9.3.1	*Temperature Monitoring Signal Characteristics*	*9-2*
9.3.2	*Pressure Signal Characteristics*	*9-3*
9.3.3	*Preconditioned Signal Characteristics*	*9-3*
9.3.4	*Analog Driver Characteristics*	*9-3*
9.4	DISCRETE COMMUNICATIONS	9-3
9.4.1	*Discrete Signal Characteristics*	*9-3*
9.4.2	*Discrete Driver and Receiver Characteristics*	*9-5*
10.	**ENVIRONMENTAL INTERFACES**	**10-1**
10.1	PAYLOAD EQUIPMENT SURFACE CLEANLINESS	10-1
10.2	EXTERNAL CONTAMINATION	10-1
10.2.1	*Molecular Column Density From Venting, Leakage, and Outgassing*	*10-1*
10.2.2	*Molecular Deposition From Materials Outgassing and Venting*	*10-1*
10.2.3	*Solid, Particulate, and Liquid Releases*	*10-2*
10.3	LASER REQUIREMENTS	10-2

TABLE OF CONTENTS (CONTINUED)

SECTION		PAGE
10.4	RADIATION REQUIREMENTS	10-2
10.4.1	*Payload Contained or Generated Ionizing Radiation*	*10-2*
10.4.2	*Single Event Effect (SEE) Ionizing Radiation*	*10-2*
10.4.3	*Total Dose Ionizing Radiation*	*10-3*
10.5	ATMOSPHERE REQUIREMENTS	10-3
10.5.1	*Humidity*	*10-3*
10.5.2	*Atomic Oxygen (AO)*	*10-3*
10.5.3	*Plasma*	*10-4*
10.5.4	*Solar Ultraviolet Radiation*	*10-4*
10.5.5	*Plume Impingement*	*10-4*
10.5.6	*Micrometeoroid and Orbital Debris (M/OD)*	*10-4*
11.	**SOFTWARE COMMUNICATIONS**	**11-1**
11.1	EXP CONTROL ASSEMBLY SOFTWARE	11-1
11.1.1	*ExPCA MIL-STD-1553 Bus Communications*	*11-1*
11.1.2	*ExPCA Medium Rate Data Link (MRDL) LAN Communications (TBC)*	*11-8*
11.2	ISS PORTABLE LAPTOP COMPUTER SYSTEM	11-8
11.3	SOFTWARE SAFETY REQUIREMENTS FOR PAYLOADS	11-8
11.4	HUNTSVILLE OPERATIONS SUPPORT CENTER (HOSC) DATA PROCESSING	11-8
12.	**EXTRAVEHICULAR ROBOTIC (EVR) AND EXTRAVEHICULAR ACTIVITY (EVA)**	**12-1**
13.	**MATERIALS AND PROCESSES INTERFACE REQUIREMENTS**	**13-1**
13.1	MATERIALS AND PROCESSES USE AND SELECTION	13-1
13.1.1	*Acceptance Criteria for Stress Corrosion Cracking (SCC)*	*13-1*
13.1.2	*Hazardous Materials and Compatibility*	*13-1*
13.1.3	*Test and Acceptance Criteria for Flammability*	*13-1*
13.1.4	*Test and Acceptance Criteria for Thermal Vacuum Stability (TVS)*	*13-2*
13.2	MATERIALS AND PARTS CERTIFICATION AND TRACEABILITY	13-2
14.	**VIEWING ENVIRONMENT**	**14-1**
14.1	FOV INTRODUCTION	14-1

TABLE OF CONTENTS (CONTINUED)

SECTION		PAGE
14.2	NEAR-FIELD FIXED FOV OBSTRUCTIONS	14-1
14.2.1	*Near-Field Fixed FOV Obstructions*	*14-1*
14.2.2	*Near-Field Moveable FOV Obstructions*	*14-1*
14.3	FAR-FIELD FOV OBSTRUCTIONS	14-6
14.3.1	*Far-Field Fixed FOV Obstructions*	*14-6*
14.3.2	*Far-Field Moveable FOV Obstructions*	*14-6*
15.	**POINTING/ATTITUDE**	**15-1**

APPENDIXES:

A	ABBREVIATIONS AND ACRONYMS	A-i
B	TRACEABILITY MATRIX	B-i
C	MERAT CASES	C-i
D	EXPRESS PALLET PAYLOADS IDD TBD LOG	D-i

LIST OF FIGURES

FIGURE		PAGE
1-1	CUSTOMER DOCUMENTATION TREE (DRAFT) FOR EXPRESS PALLET	1-7
3-1	SPACE SHUTTLE ORBITER STRUCTURAL COORDINATE SYSTEM	3-2
3-2	INTERNATIONAL SPACE STATION REFERENCE COORDINATE SYSTEM	3-3
3-3	INTEGRATED TRUSS SEGMENT S3 COORDINATE SYSTEM	3-4
3-4	EXP STRUCTURAL LAUNCH COORDINATE SYSTEM	3-5
3-5	EXP STRUCTURAL ON-ORBIT COORDINATE SYSTEM	3-6
3-6	EXPA LAUNCH COORDINATE SYSTEM (TBC)	3-8
3-7	EXPA ON-ORBIT COORDINATE SYSTEM (TBC)	3-9
3-8	EXP ISS NOMENCLATURE (ZENITH PAYLOADS)	3-10
3-9	EXP ISS NOMENCLATURE (NADIR PAYLOADS)	3-11
3-10	ULC STRUCTURAL COORDINATE SYSTEM	3-12
3-11	SIDEWALL CARRIER STRUCTURAL COORDINATE SYSTEM.	3-13
3-12	EXPA CONFIGURATION (TBC)	3-16

TABLE OF CONTENTS (CONTINUED)

FIGURE		PAGE
3-13	EXPA PAYLOAD MOUNTING PROVISIONS (TBC)	3-17
3-14	PAYLOAD/EXPA ATTACHMENT POINT DETAILS	3-18
3-15	CONNECTOR PANEL 1 LOCATION AND CONFIGURATION	3-19
3-16	CONNECTOR PANEL 2 LOCATION AND CONFIGURATION	3-20
3-17	PAYLOAD/GSE HARDPOINTS	3-24
3-18	PAYLOAD ENVELOPE FOR EXPA-MOUNTED PAYLOADS (TBC)	3-25
3-19	PAYLOAD ENVELOPE LOCATION ON EXPA (TBC)	3-26
3-20	REQUIREMENTS FOR ROUNDING EXPOSED EDGES 0.25 IN (6.4 MM) THICK OR THICKER	3-28
3-21	REQUIREMENTS FOR ROUNDING EXPOSED EDGES 0.12 TO 0.25 IN (3.0 TO 6.4 MM) THICK	3-28
3-22	REQUIREMENTS FOR ROUNDING EXPOSED EDGES 0.02 TO 0.12 IN (0.5 TO 3.0 MM) THICK	3-29
3-23	REQUIREMENTS FOR CURLING OF SHEETS LESS THAN 0.02 IN (0.5 MM) THICK	3-29
3-24	REQUIREMENTS FOR ROUNDING OF CORNERS LESS THAN 1.0 IN (25 MM) THICK	3-30
3-25	REQUIREMENS FOR ROUNDING OF CORNERS GREATER THAN 1.0 IN (25 MM) THICK	3-31
4-1	DIRECTIONS OF LOAD FACTORS	4-2
6-1	EXPRESS PALLET POWER DISTRIBUTION SYSTEM OVERVIEW – ON-ORBIT/STAY-ALIVE POWER	6-2
6-2	EXPRESS PALLET POWER DISTRIBUTION SYSTEM OVERVIEW – EMERGENCY POWER	6-3
6-3	120-VDC TRANSIENT VOLTAGE CHARACTERISTIC – STAY-ALIVE (ORBITER) MISSION PHASE (TBC)	6-7
6-4	120-VDC TRANSIENT VOLTAGE CHARACTERISTIC – ON-ORBIT (ISS) MISSION PHASE (TBC)	6-8
6-5	120-VDC SOURCE IMPEDANCE CHARACTERISTICS – STAY-ALIVE (ORBITER) MISSION PHASE	6-9
6-6	120-VDC SOURCE IMPEDANCE CHARACTERISTICS – ON-ORBIT (ISS) MISSION PHASE	6-10
6-7	120-VDC ON-ORBIT (ISS) NON-NORMAL TRANSIENT LIMITS	6-12

TABLE OF CONTENTS (CONTINUED)

FIGURE		PAGE
6-8	120-VDC EMERGENCY FEED SOFT START CHARACTERISTIC (ISS POWER SOURCE)	6-15
7-1	CS06 AND RS02 PAYLOAD EQUIPMENT LIMIT	7-8
7-2	NARROWBAND E-FIELD EMISSIONS LIMITS	7-10
7-3	PAYLOAD ISOLATION AND GROUNDING FOR EXP	7-15
9-1	EXP PAYLOAD C&DH INTERFACES	9-1
9-2	INPUT AMPLIFIER FOR ANALOG SIGNALS TO BE DIGITIZED (EXPCA ANALOG RECEIVER CIRCUIT)	9-4
9-3	EXPCA DISCRETE RECEIVER CIRCUIT AND DRIVER CIRCUIT FOR DISCRETE COMMUNICATIONS	9-6
11-1	EXP INTERFACE DIAGRAM FOR EXPCA TO PAYLOADS	11-2
11-2	PAYLOAD PEP COMMAND	11-3
11-3	END-TO-END SERVICE REQUEST FOR PAYLOAD FLOW	11-3
11-4	EXP PAYLOAD HEALTH AND STATUS FORMAT	11-6
14-1	EXP NEAR-FIELD FIXED VIEWING ENVIRONMENTS (TBC)	14-2
14-2	SCUFF PLATE DETAILS	14-3
14-3	EXP SPACING ON ISS	14-5

LIST OF TABLES

TABLE		PAGE
1-I	STANDARD EXP PAYLOAD	1-5
3-I	EXP ISS LOCATION NOMENCLATURE CROSS REFERENCE	3-14
3-II	COORDINATE SYSTEM CROSS REFERENCE FOR EXP ON ISS	3-15
3-III	ATTACHMENT BOLT RECEPTACLE FORCE ALLOWABLES FOR EXP	3-22
3-IV	EXP PAYLOAD ENVELOPE COORDINATES (TBC)	3-27
4-I	EXP COMPONENT CENTER OF GRAVITY PRELIMINARY DESIGN LOAD FACTORS	4-2
4-II	EMERGENCY LANDING LOAD FACTORS	4-3
4-III	HIGH FREQUENCY RANDOM VIBRATION ENVIRONMENT FOR EXP PAYLOAD EQUIPMENT DESIGN (TBC)	4-4
4-IV	PAYLOAD CG REQUIREMENTS	4-5
4-V	EVA-INDUCED LOADS	4-7

TABLE OF CONTENTS (CONTINUED)

TABLE		PAGE
4-VI	LIMIT LOAD FACTORS (G) FOR GROUND-HANDLING, ROAD, AIR, AND BARGE OPERATIONS	4-9
5-I	EXP PAYLOAD ENVIRONMENTAL CONDITIONS	5-2
5-II	EXPA MAXIMUM AND MINIMUM TEMPERATURES	5-3
6-I	120-VDC VOLTAGE RANGE (TBC)	6-6
6-II	120-VDC RIPPLE VOLTAGE CHARACTERISTIC	6-7
6-III	120-VDC FEED SOURCE IMPEDANCE CHARACTERISTIC	6-8
6-IV	PAYLOAD MAXIMUM POWER AVAILABILITY (TBC)	6-15
7-I	CIRCUIT EMC CLASSIFICATIONS	7-2
7-II	EXP PAYLOADS EDGE-TO-EDGE BUNDLE SEPARATION REQUIREMENTS	7-3
7-III	CE01 LIMITS	7-5
7-IV	CE03 LIMITS	7-6
7-V	CE07 LIMITS	7-6
7-VI	CS01 LIMITS	7-7
7-VII	RE02 LIMITS	7-9
7-VIII	RS03 LIMITS	7-11
8-I	EXPA CONNECTOR INTERFACE DEFINITION (TBC)	8-2
11-I	EXP PAYLOAD-RELATED EXPCA INTERFACE IDENTIFICATION	11-2
11-II	PAYLOAD MIL-STD-1553B EXTERNAL INTERFACE DATA ELEMENT (8)	11-4

SECTION 1, INTRODUCTION

1.1 PURPOSE

This IDD defines and controls the design of the interfaces between the EXPRESS Pallet Adapter (ExPA), payloads, and associated environments (subject to the limitations as discussed in the Abstract). Information on the cargo bay is included in this document for completeness; however, it is for reference only, since it is controlled in the orbiter IDD, NSTS 21000-IDD-ISS. Payload support hardware located in the middeck for launch or landing and moved to the ExP on orbit must comply with the requirements in NSTS 21000-IDD-MDK. The definitions for IDD, Payload-Unique ICD, and Flight-Unique Interface Control Annex (ICA) are provided below.

This IDD should be used in conjunction with the Payload Accommodations Handbook (PAH) for EXPRESS Pallet Payloads, SSP 52000-PAH-EPP. The PAH describes the accommodations and capabilities of the ExP and associated ISS and Space Transportation System (STS) interfaces. The PAH does not levy any requirements since that is the purpose of this IDD. The requirements in this IDD will be verified in accordance with the Payload Verification Plan (PVP) for ExP payloads. The PVP defines the verification methodology and data requirements for verifying each of the requirements in the IDD. The PVP does not impose any additional interface or design requirements.

1.1.1 Definition of IDD

A. Levies the associated design requirements and defines the interfaces which are provided by the ExP for payloads that utilize ExP, ULC, and Sidewall Carrier.

B. Defines and controls constraints which shall be observed by the payload community in using the interfaces defined.

C. Establishes commonality with respect to analytical approaches, analytical models, technical data, and definitions for integrated analysis by interfacing parties.

D. This IDD contains data from the orbiter IDD in order to establish a common document for payloads. The middeck requirements are applicable only to the payload support hardware that uses the middeck for transportation.

E. This IDD contains data from NSTS 21000-IDD-ISS, Shuttle Orbiter/Space Station Interface Definition Document. These requirements are applicable to payloads transported in the orbiter cargo bay.

1.1.2 Definition of Payload-Unique ICD

A. Defines and controls the design of interfaces (standard, nonstandard, and unique) between the ExPA and payload.

B. Selects the IDD interfaces and defines selectable parameters and unique interfaces in the ExP facility.

C. Defines and controls the constraints which shall be observed by both the ExPA and the payload in using the interfaces so defined.

D. Establishes commonality with respect to analytical approaches, analytical models, technical data, and definitions for integrated analysis by both interfacing parties.

E. Development of an ICD based on this IDD will fulfill the requirements for ExP and Shuttle.

F. The ExP Project will provide an integrated set of requirements to the ISS Program for the applicable payload complement.

1.1.3 Definition of Flight-Unique ICA

The ICA is a document specific to the Shuttle accommodations, interfaces, and requirements. This document will be applicable to all of those ExP payloads that launch or land in the orbiter. The ICA will:

A. Define the interfaces and resource requirements (power, volume, mass, etc.) which shall be provided by the Shuttle for all payloads on a particular flight.

B. Document the exceedances to NSTS 21000-IDD-ISS specified interfaces/requirements via approved Change Requests (CR).

The information from the payload-unique ICD will be used to develop the necessary ICA inputs. The ICA is an integrated document that includes all applicable payload information for Shuttle requirements.

1.1.4 Waivers, Deviations, and Exceedances

Unique ICDs are derivatives of this IDD and do not require Space Shuttle Program or ISS Program approval if they remain within the interface design parameters defined by this document.

Any exceedance or deviation from the capabilities or services defined in this IDD rationale for acceptance. All waivers, deviations, and exceedances must be approved by the shall be documented in a unique paragraph of the derived ICD. This unique paragraph shall document the specific requirement violated, a description of the existing condition, and a ISS Payloads Office and the Space Shuttle Program.

Definitions:

Exceedances: Documentation of a condition that does not comply with stated requirements but does not add any risk due to intended usage or configuration and can be shown to be acceptable without special analysis or controls.

Deviation: A noncompliance that requires additional analysis or control to eliminate risk and is acceptable when properly documented.

Waiver: A condition that does not comply with the requirements of this IDD could add risk and requires special controls/analysis to assure adequate flight margins.

1.2 SCOPE

The requirements defined in this document apply to the design/development, transportation, launch/landing, and on-orbit phases of the payload cycle.

This IDD also identifies safety interface and design requirements with which ExP payloads must comply; however, the Payload Developers (PD) are still required to show compliance via the safety review process to NSTS 1700.7 and ISS Addendum, KHB 1700.7, and NSTS 18798 (Interpretation Letters). The safety implementation process is defined in NSTS 13830. Each PD is responsible for development and submittal of required safety data packages and also for the coordination and completion of each safety review via the Payload Safety Review Panel (PSRP) executive secretary. The unique payload safety hazards and associated verification data must be coordinated directly with the PSRP. The PD must provide a copy of the applicable safety data package to the ExP Engineering Integration (EI) representative so that an integrated hazard assessment can be completed.

Identification of resource requirements (i.e., power, heat dissipation, data, volume, mass properties) is required to be performed and included in the payload-specific integration data files in the Payload Data Library (PDL).

1.3 EXP PAYLOAD ACCOMMODATIONS

STANDARD EXPA PAYLOAD

ExP payloads will be categorized for integration purposes as “standard” or “nonstandard.” This classification is based upon a payload conformance to the standard defined in Table 1-I. Classification of a payload based on Table 1-I provides to ExP EI a top level indication regarding the integration complexity and allows the integrator an opportunity to assess any impacts. All payloads, regardless of their complexity, are required to support all generic integration templates as shown in SSP 52000-PAH-EPP.

NONSTANDARD EXP PAYLOAD ACCOMMODATIONS

Payloads with requirements exceeding standard ExPA allocations shown in Table 1-I are “nonstandard.” Payloads with requirements for resources/interfaces not offered are also “nonstandard.” This determination is dependent on the type of exceedance of the standard allocation or complexity of the unique interface. These payloads can be integrated onto the ExP. The “nonstandard” payloads may be limited in manifesting possibilities or may necessitate alteration of the standard ExP payload analytical/physical integration template(s) shown in SSP 52000-PAH-EPP.

1.3.1 Precedence

The order of precedence of documents identified herein shall be as follows: NSTS 1700.7 and ISS Addendum, KHB 1700.7, Orbiter IDD (NSTS 21000-IDD-ISS), Attached Payload IRD (SSP 57003), ExP IDD, unique EXPRESS Pallet Integration Agreement (EIA), payload-unique ICDs, flight-unique ICAs, payload-specific PDL data files, Government specifications, Government standards, military (MIL) specifications, MIL standards, contractor specifications, contractor standards, and other documents.

1.3.2 Effectivity

Unless otherwise specified, the interfaces defined and controlled herein are applicable to the operational configuration of the ISS or STS.

1.4 CHANGE POLICY

All changes to this document must be controlled in accordance with the procedures prescribed herein and by SSP 41170, Configuration Management Requirements. Dispositioned changes shall reflect program decisions and will record new, changed, and/or deleted requirements.

TABLE 1-I STANDARD EXP PAYLOAD (Sheet 1 of 2)

DISCIPLINE	STANDARD ACCOMMODATION (per ExPA)	NOTES/ REMARKS
Mass	500 lb (226.7 kg) per adapter (excluding ExPA)	
Center of Gravity	CG varies as a function of mass.	Note 1
Frequency	First mode fundamental frequency $\geq$35 Hz	
Envelope	Maximum volume 34-in (864 mm) depth x 46-in (1168 mm) width x 49-in (1245 mm) height	Note 2
Power	416 W capability at 120 Vdc (2 feeds) 166 W capability at 28 Vdc (2 feeds)	Note 3, Note 4
C&DH	MIL-STD-1553 bus [2 Remote Terminals (RT) at each ExPA] Analog (6 inputs) Discrete (6 programmable I/O) Two Ethernet interfaces (shared with other payloads on Pallet)	Note 5
Thermal	No active thermal control is provided to payloads by ExP. No more than 50 W per adapter can be conducted to the ExP.	
EVA/EVR	Payloads should not have any EVA/EVR requirements. EVR/EVA interfaces are satisfied by ExPA. Payloads should have no planned release of hardware from the ExPA or payload.	
Late Access	No payload requirements for access after turnover to KSC	
Early Removal	No payload requirements for early removal of hardware after returning from ISS	
Transmission	No Radio Frequency (RF) or microwave, transmitters or receivers.	
Pyrotechnics	No pyrotechnic devices on payloads.	
Propulsive Devices	No propulsive devices on payloads.	

TABLE 1-I STANDARD EXP PAYLOAD (Sheet 2 of 2)

NOTES:

1. Reference Center of Gravity (CG) versus mass table in Section 4, Table 4-IV.
2. Maximum envelope is defined. Temporary exceedances make a payload nonstandard. Reference Table 3-IV.
3. The standard power allocations, as stated in this table, are derived by dividing the maximum power allocation by six for both the 120-Vdc and 28-Vdc feeds. The maximum power delivered to any one ExPA may be 2.5 kW (inclusive of both the 120-Vdc and 28-Vdc feeds). 2.5 kW is also the maximum power available for the entire ExP payload complement. If supplied to a single ExPA, this maximum is subject to at least a power reduction for the stay-alive power requirements of the other payloads. This maximum power will be available for limited durations and is subject to ISS operational timelining of the co-resident ExP power allocations.
4. Stay-alive power for six ExPAs is defined in Table 6-IV.
5. 1553 and Ethernet interfaces are shared and require payload-provided data storage/buffers.

1.5 DOCUMENTATION TREE

The documentation tree is shown in Figure 1-1.

1.6 TECHNICAL POINT OF CONTACT

Name	Organization	Discipline	Phone/Fax/Email
Tom Lynch	MSFC/EXPRESS Pallet Engineering Integration (EI) Mail Code: JA62	Book Manager	(256) 544-3741 (256) 544-6806 tom.lynch@msfc.nasa.gov

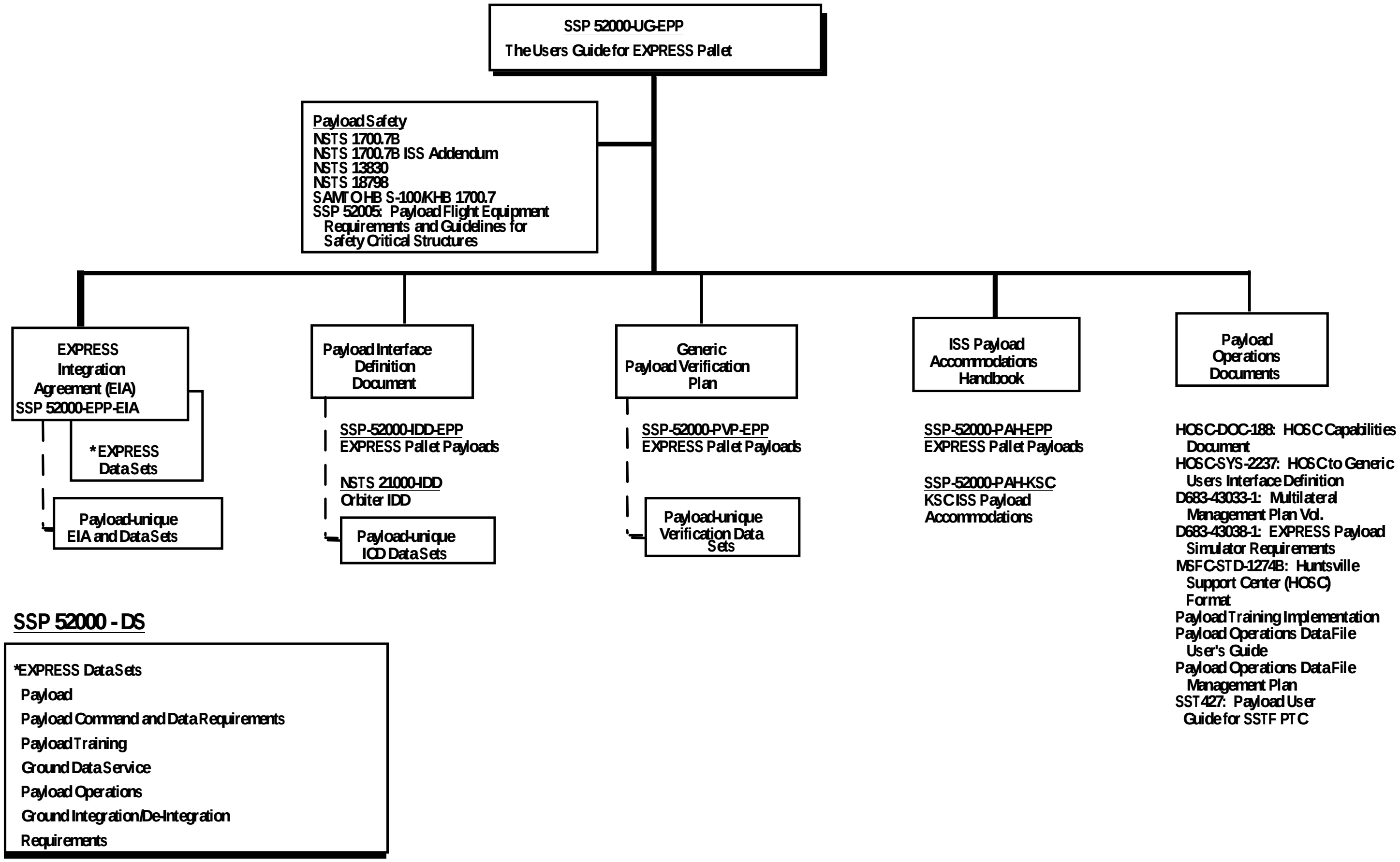

FIGURE 1-1 CUSTOMER DOCUMENTATION TREE (DRAFT) FOR EXPRESS PALLET

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SECTION 2, DOCUMENTS

2.1 INTRODUCTION

There are two categories of documents included in the IDD. Applicable documents are those that a verification item is traced to as the source. Reference documents are those that are noted in the text but do not have verification requirements associated with them (for example they may be noted in paragraphs included as “Design Guidance”). The IDD categorizes documentation in this way to minimize any potential PD’s reference of information sources not contained herein.

2.2 APPLICABLE DOCUMENTS

The following documents of the exact issue shown shall form a part of this document to the extent specified herein. Unless the exact issue and date are identified, the “Current Issue” cited in the contract Applicable Documents List (ADL) applies. Inclusion of applicable documents herein does not in any way supersede the contractual order of precedence. In the event of conflict between the documents referenced and the contents of this document, the contents of this document shall be considered a superseding requirement.

2.2.1 Government Documents

FED-STD-101C October 14, 1988	Test Procedures for Packaging Materials
ICD-A-21321 February 2, 1996	Shuttle Orbiter/Assembly Power Converter Unit (APCU) Cargo Element Interfaces
KHB 1700.7B September 1, 1992	Space Transportation System Payload Ground Safety Handbook
MIL-C-5541C April 14, 1981	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-C-27500H December 10, 1997	Cable Electrical, Cable Special Purpose, Electrical Shielded and Unshielded
MIL-STD-1553B January 15, 1996	Digital Time Division Command/Response Multiplex Data Bus

MIL-STD-1686C October 25, 1995	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)
MSFC-SPEC-522B March 15, 1988	Design Criteria for Stress Corrosion Cracking
MSFC-STD-486B November 1, 1992	Torque Limits for Threaded Fasteners
MSFC-STD-561A February 1995	Threaded Fasteners, Securing of Safety-Critical Flight Hardware Used on Shuttle Payloads and Experiments
MSFC-STD-1274B, Vol. 2 June 1995	MSFC HOSC Telemetry Format Standard, Packets
NASA-STD-5003 (previously NHB 8071.1) October 7, 1996	Fracture Control Requirements for Payloads Using the National Space Transportation System (NSTS)
NASA-STD-6001 February 9, 1998	Flammability, Odor, and Offgassing and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion
NASM-1312-7 April 1998	Fastener Test Methods - Method 7, Vibrations
NSTS 08307 October 13, 1989	Criteria for Preloaded Bolts
NSTS 13830C August 8, 1998	Implementation Procedure for NSTS Payloads System Safety Requirements
NSTS 1700.7B March 21, 1997	Safety Policy and Requirements for Payloads Using the Space Transportation System
NSTS 1700.7B, ISS Addendum December 8, 1995	Safety Policy and Requirements for Payloads Using the International Space Station

NSTS-ISS-18798B December 10, 1998	Interpretation of NSTS Payload Safety Requirements
NSTS 21000-IDD-ISS, Rev. A August 13, 1998	Shuttle Orbiter/International Space Station Interface Definition Document
SSP 30237D July 21, 1998	Electromagnetic Emission and Susceptibility Requirements
SSP 30240D September 21, 1998	Space Station Grounding Requirements
SSP 30245D June 4, 1998	Space Station Electrical Bonding Requirements
SSP 30420B June 1, 1993	Space Station Electromagnetic Ionizing Radiation and Plasma Environment Definition and Design Requirements
SSP 30425B February 8, 1994	Space Station Program Natural Environment Definition for Design
SSP 50005B August 19, 1995	International Space Station Flight Crew Integration Standard (NASA-STD-3000/T)
SSP 52005B February 1998	International Space Station Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures
SSP 52050A November 4, 1998	Software ICD Part 1, International Standard Payload Rack to ISS
SSP 52051 July 1996	User Electric Power Specification and Standards
SSP 52052-IDD-PCS	Interface Definition Document for the ISS Portable Computer System (PCS)
SSP 52055 September 30, 1998	EXPRESS Pallet System Development Specification
SSP 57003 (not baselined)	Attached Payload Interface Requirements Document, ISS Program

SSQ 21635G May 12, 1997	Connectors and Accessories Electrical Circular Miniature IVA/EVA Compatible Space Quality
SSQ 21655E September 24, 1998	General Specification for Cable, Electrical MIL-STD-1553 Data Bus Space Quality

2.2.2 Non-Government Documents

ASTM-E1559 January 1, 1993	Standard Test Methods for Contamination Outgassing Characteristics of Spacecraft Materials
ISO/IEC 8802.3 (ANSI/IEEE 802.3) January 1, 1996	Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications
SAE AS4536 January 4, 1993	Safety Cable Kit Procurement Specification and Requirements for Use

2.3 REFERENCE DOCUMENTS

Reference documents are those that are noted in the text but do not have verification requirements associated with them. Reference documents are listed as an aid to help the PDs better understand the information presented in this IDD.

2.3.1 Government Documents

ICD-2-19001L January 15, 1998	Shuttle Orbiter Cargo Standard Interface (CORE)
JSC 26557I, Vol. I September 1998	ISS On-Orbit Assembly, Modeling, and Mass Properties Data Book
JSC Letter TA94-057	Modified Fracture Control Criteria and Guidelines for Payloads
JSC SN-C-0005C	National Space Transportation System Specification, Contamination Control Requirements for the Space Shuttle Program
NASM 33540 June 30, 1998	Safety Wiring and Cotter Pinning, General Practices for

MSFC-HDBK-527F/JSC 09604 December 29, 1988	Materials Selection List for Space Hardware Systems
MSFC-STD-531 December 13, 1978	High Voltage Design Criteria
NASA-STD-8739.4 February 9, 1998	Crimping, Interconnecting Cables, Harnesses, and Wiring
NSTS 07700K, Vol. XIV November 13, 1998	Space Shuttle System Payload Accommodations
NSTS 08242A May 6, 1994	Limitations for Non-Flight Materials and Equipment Used in and Around Space Shuttle Orbiter Vehicle
NSTS 21000-IDD-MDK, Vol. XIV, Rev. B	Shuttle/Payload Interface Definition Document for Middeck Accommodations
SSP 30219E November 19, 1998	Space Station Reference Coordinate Systems
SSP 30426D January 21, 1994	Space Station External Contamination Control Requirements
SSP 30512C June 3, 1994	Space Station Ionizing Radiation Emission and Susceptibility Requirements for Ionizing Radiation Environment Capability
SSP 41170 November 13, 1998	Configuration Management Requirements
SSP 41175-02 July 31, 1998	Software ICD, Part 1, Station Management and Control to ISS Book 2, General Interface Software Interfaces Requirements
SSP 41177-05A June 10, 1996	Software ICD, Part 1, GN&C-to-ISS Book 5, GPS Interface
SSP 42131B August 1, 1997	Integrated Truss Segments P3 and S3 to Attached Payloads and Unpressurized Cargo Carriers Interface Control Document

SSP 52000-PAH-EPP	ISS Payload Accommodations Handbook for EXPRESS Pallet
SSP 52000-PAH-LSP (not baselined)	Launch Site Processing Payload Accommodations Handbook for ISS
SSP 52000-PVP-EPP	Blank Book Payload Verification Plan for EXPRESS Pallet

2.3.2 Non-Government Documents

ASTM-E595 January 1, 1993	Standard Test Method of Total Mass Loss and Collected Volatile Materials from Outgassing in a Vacuum Environment
S683-29523K October 20, 1998	United States Laboratory Specification

2.4 BOEING NORTH AMERICAN (BNA) DRAWINGS AND SPECIFICATIONS

All part numbers listed in this IDD beginning with prefixes V602-, V646-, V070-, or V733- and all specification numbers beginning with the letters MC, MD, or ME are RI Company documents that pertain to drawings peculiar to the specific middeck payloads.

2.5 INSTITUTO NACIONAL DE PESQUISAS ESPACIASIS (INPE) DRAWINGS

All part numbers listed in this IDD beginning with the number(s) **TBD#2-01** are INPE drawings or documents.

SECTION 3, PHYSICAL AND MECHANICAL INTERFACES

3.1 GEOMETRIC RELATIONSHIPS

Integration of the ExP and payloads on ISS and Shuttle involves the use of several defined and undefined coordinate systems and geometric relationships. These established and ExP-unique coordinate systems are defined in the following paragraphs.

3.1.1 Space Shuttle Orbiter Coordinate Systems

3.1.1.1 Space Shuttle Orbiter Structural Coordinate System

The Space Shuttle orbiter structural coordinate system is shown in Figure 3-1.

3.1.1.2 Space Shuttle Orbiter Cargo Bay Attachment Locations

The Space Shuttle orbiter cargo bay locations are identified in paragraph 3.3.1.1.1 of NSTS 21000-IDD-ISS.

3.1.2 ISS Coordinate Systems

3.1.2.1 ISS Reference Coordinate System

The ISS reference coordinate system is shown in Figure 3-2.

3.1.2.2 ISS Integrated Truss Segment (ITS) S3 Coordinate System

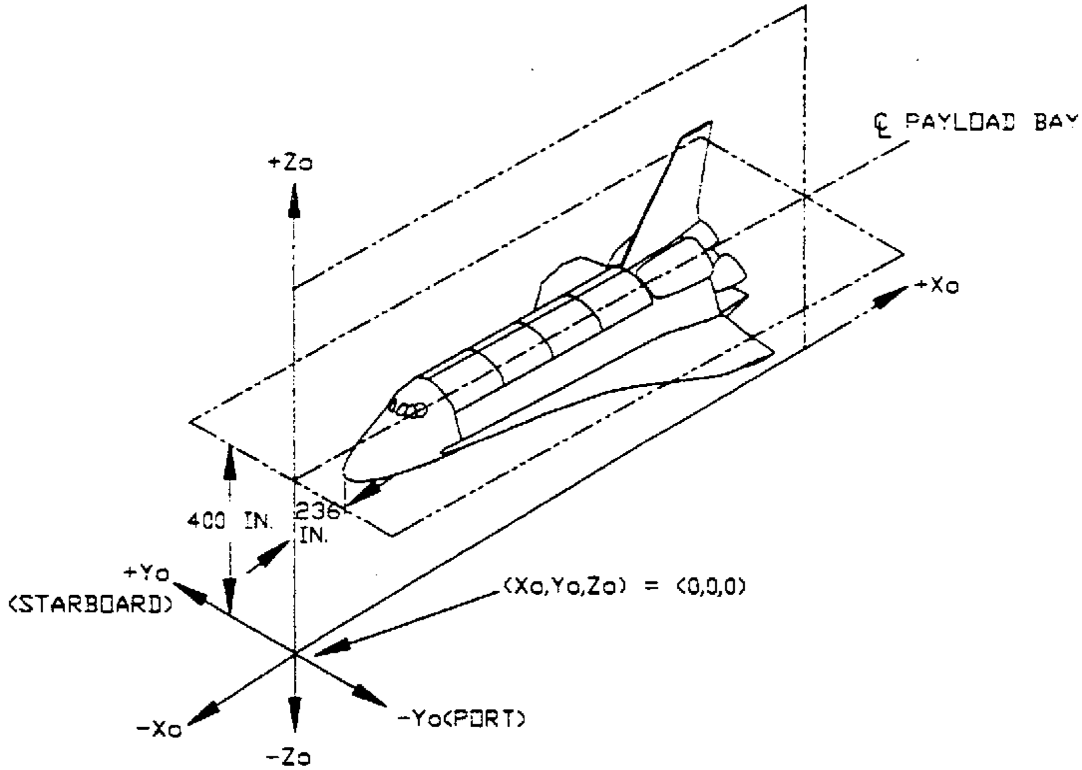
The ISS ITS S3 coordinate system is shown in Figure 3-3.

3.1.3 ExP Coordinate Systems and Nomenclature

3.1.3.1 ExP Structural Coordinate System

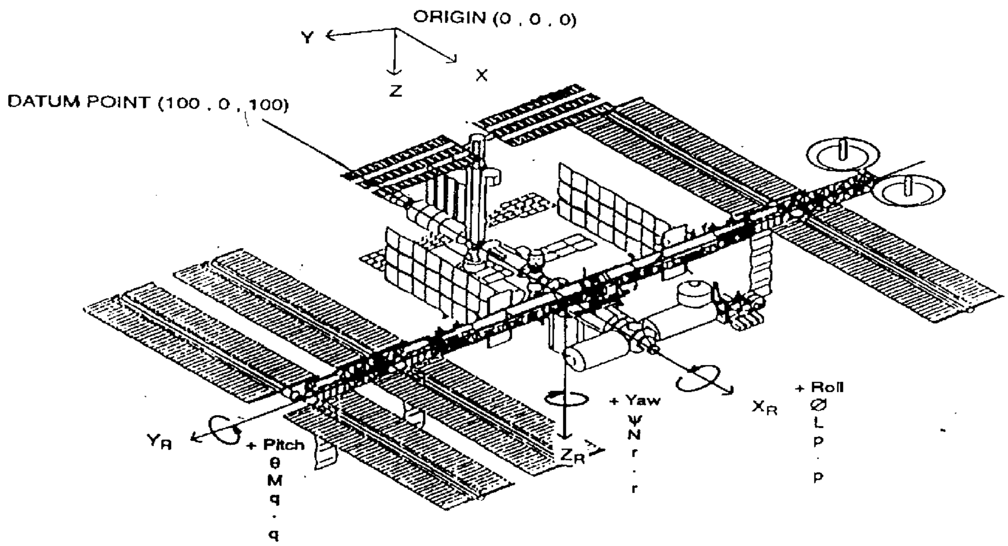
The ExP structural coordinate system for launch in the Space Shuttle orbiter is shown in Figure 3-4.

The ExP structural coordinate system for on-orbit operations on ISS is shown in Figure 3-5.



NAME:	Space Shuttle Orbiter Coordinate System
TYPE:	Rotating Right-Handed Cartesian, body-Fixed
DESCRIPTION:	This coordinate system is consistent with NSTS 07700, Volume XIV, Attachment 1, ICD-2-19001, Shuttle Orbiter/Cargo Standard Interfaces.
ORIGIN:	The origin is located in the orbiter plane of symmetry at a point 400 in (10160 mm) below the center line of the payload bay and 236 in (5994 mm) forward of the orbiter nose.
ORIENTATION:	X_o The X-axis is the vehicle plane of symmetry, parallel to and 400 in (10160 mm) below the centerline of the payload bay. The positive X-axis is from the nose of the vehicle toward the tail.
	Z_o The Z-axis is in the vehicle plane of symmetry, perpendicular to the X-axis. The positive Z-axis is upward in the landing attitude.
	Y_o The positive Y-axis completes the right-handed Cartesian system.
SUBSCRIPT:	O

FIGURE 3-1 SPACE SHUTTLE ORBITER STRUCTURAL COORDINATE SYSTEM



NAME: ISS Reference Coordinate System

TYPE: Rotating Right-Handed Cartesian, Body-Fixed

DESCRIPTION: This coordinate system is derived using the Local Vertical Local Horizontal (LVLH) flight orientation. When defining the relationship between this coordinate system and another, the Euler angle sequence to be used is a yaw, pitch, roll sequence around the Z_R, Y_R, and X_R axes, respectively.

This coordinate system is consistent with Figure 4.0-2 of SSP 30219, Space Station Reference Coordinate System.

ORIGIN: The datum point is located at the geometric center of ITS S0. The origin is located such that the datum point is located at X_R = 100 in (2540 mm), Y_R = 0, and Z_R = 100 in (2540 mm).

ORIENTATION: X_R The X-axis is parallel to the longitudinal axis of the U.S. Laboratory. The positive X-axis is in the forward (or ram) direction.

Y_R The Y-axis is coincident with the alpha joint rotational axis. The positive Y-axis is in the starboard direction.

Z_R The positive Z-axis is in the direction of nadir and completes the rotating right-handed Cartesian system.

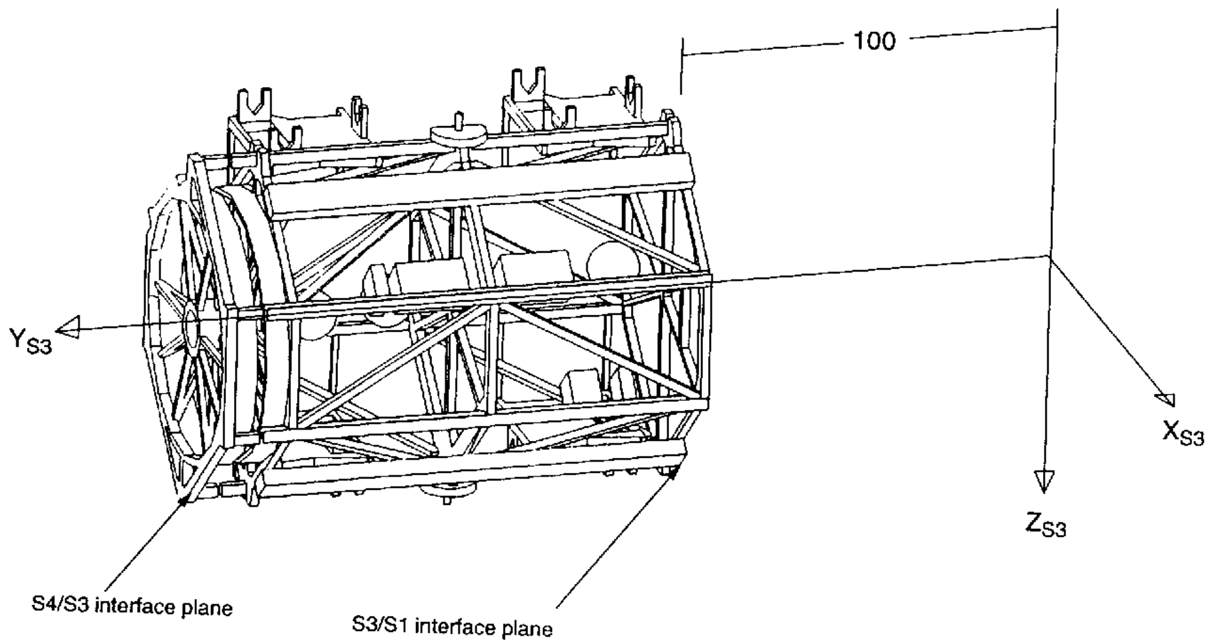
L, M, N: Moments about X_R, Y_R, and Z_R axes, respectively.

p, q, r: Body rates about X_R, Y_R, and Z_R axes, respectively.

p, q, r: Angular body acceleration about X_R, Y_R, and Z_R axes, respectively.

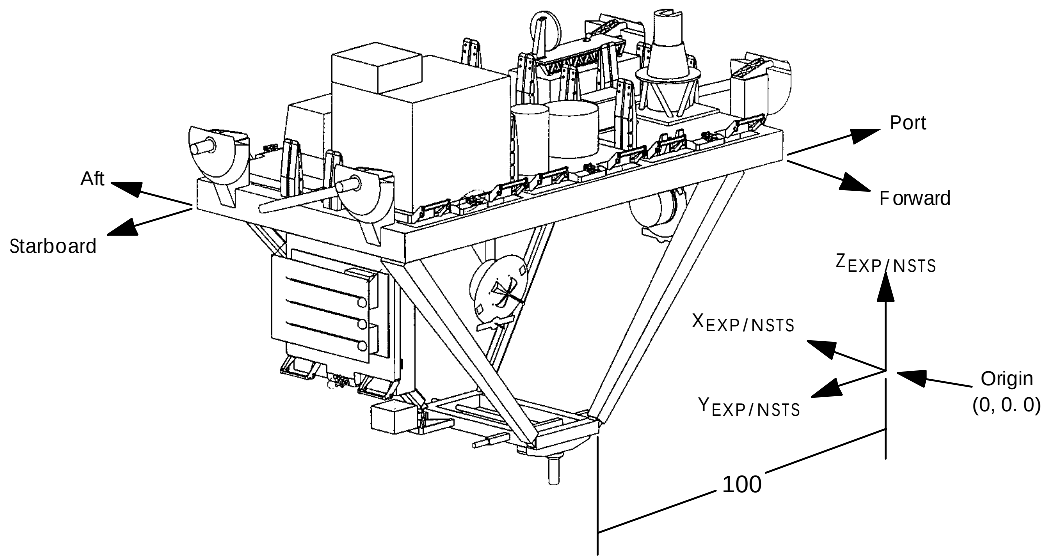
SUBSCRIPT: R

FIGURE 3-2 INTERNATIONAL SPACE STATION REFERENCE COORDINATE SYSTEM



NAME:	Integrated Truss Segment S3 Coordinate System	
TYPE:	Rotating Right-Handed Cartesian, Body-Fixed	
DESCRIPTION:	This coordinate system is defined using the interface plane between the S3 ITS and the S1 ITS. The coordinate system is consistent with Figure 10.0-3 of SSP 30219, Space Station Reference Coordinate System.	
ORIGIN:	The origin is located at a point 100 in (2540 mm) from the outer face of the S3 ITS bulkhead that interfaces with the S1 ITS.	
ORIENTATION:	X_{S3}	The X-axis is perpendicular to the alpha joint rotational axis. The positive X-axis is toward the Mobile Transporter rails.
	Y_{S3}	The Y-axis is coincident with the alpha joint rotational axis. The positive Y-axis is toward the ITS.
	Z_{S3}	The Z-axis is parallel to the trunnion pin longitudinal axis. The positive Z-axis is toward the module cluster support structure and completes the right-handed Cartesian system.
SUBSCRIPT:	S3	

FIGURE 3-3 INTEGRATED TRUSS SEGMENT S3 COORDINATE SYSTEM



NAME: ExP Structural Launch Coordinate System

TYPE: Rotating Right-Handed Cartesian, Body-Fixed

DESCRIPTION: The ExP will be attached to the Space Shuttle orbiter so that the coordinate axes are nominally parallel to the same sense as the Space Shuttle orbiter axes X_o, Y_o, and Z_o.

ORIGIN: The origin is located at a point 100 in (2540 mm) from the forward, port corner of the Payload Attach System frame of the ExP structure in the port direction.

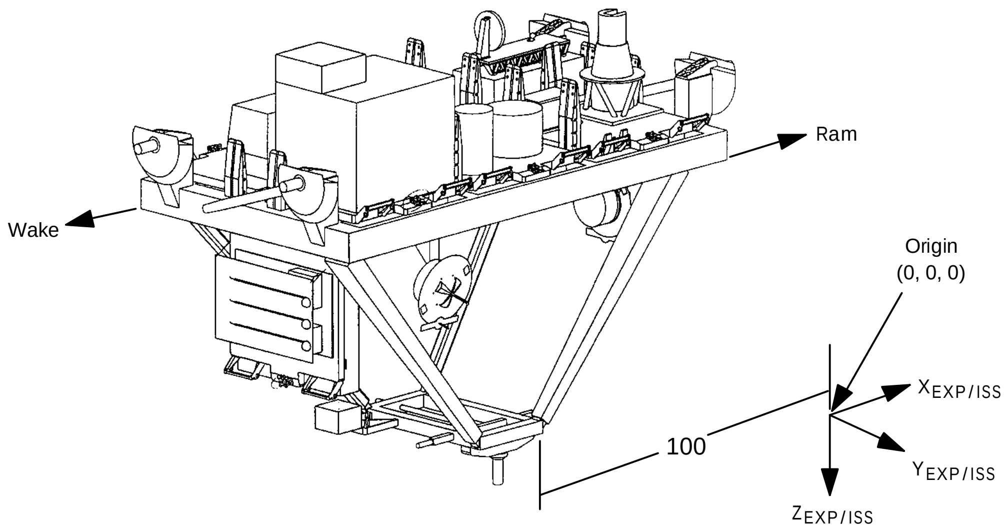
ORIENTATION: $X_{EXP/NSTS}$ The X-axis is parallel to the Space Shuttle orbiter X_O-axis. The positive X-axis is from the nose of the vehicle toward the tail.

$Y_{EXP/NSTS}$ The Y-axis is parallel to the Space Shuttle orbiter Y_O-axis. The positive Y-axis is toward the starboard side of the Space Shuttle orbiter.

$Z_{EXP/NSTS}$ The Z-axis is parallel to the Space Shuttle orbiter Z_O-axis. The positive Z-axis is upward in the landing attitude.

SUBSCRIPT: EXP/NSTS

FIGURE 3-4 EXP STRUCTURAL LAUNCH COORDINATE SYSTEM



NAME:	ExP Structural On-orbit Coordinate System
TYPE:	Rotating Right-Handed Cartesian, Body-Fixed
DESCRIPTION:	The ExP will be attached to the Space Station ITS so that the coordinate axes are nominally parallel to the same sense as the Space Station Body-Fixed axes X_R, Y_R, and Z_R, and ITS S3 coordinate system axes X_{S3}, Y_{S3}, and Z_{S3}.
ORIGIN:	The origin is located at a point 100 in (2540 mm) from the ram starboard corner of the Payload Attach System frame of the ExP structure when attached to the zenith side of the ITS and the ram, port corner when attached to the nadir side of the ITS.
ORIENTATION:	$X_{EXP/ISS}$ The X-axis is parallel to the Space Station X_R-axis and positive in the direction of flight when attached to the Space Station.
	$Y_{EXP/ISS}$ The Y-axis is parallel to the Space Station Y_R-axis and positive toward starboard when attached to the zenith side of the ITS and positive toward port when attached to the nadir side of the ITS.
	$Z_{EXP/ISS}$ The Z-axis is parallel to the Space Station Z_R-axis and positive toward nadir when attached to the zenith side of the ITS and positive toward zenith when attached to the nadir side of the ITS.
SUBSCRIPT:	EXP/ISS

FIGURE 3-5 EXP STRUCTURAL ON-ORBIT COORDINATE SYSTEM

3.1.3.2 ExPA Coordinate System

The ExPA structural coordinate system for launch in the Space Shuttle orbiter is shown in Figure 3-6.

The ExPA structural coordinate system for on-orbit operations on ISS is shown in Figure 3-7.

3.1.3.3 ExP Nomenclature

The nomenclature for ExPs with payloads mounted on the ISS is defined in Figures 3-8 and 3-9 for the zenith and nadir sides of the ITS, respectively.

An ExP to ISS attached payload location nomenclature cross reference is shown in Table 3-I. The ISS attached payload nomenclature is defined in SSP 42131, Space Station Program ITS P3 and S3 to Attached Payloads and Unpressurized Cargo Carriers (UCC) Standard Interface Control Document.

3.1.4 ULC Coordinate System

The ULC structural coordinate system is shown in Figure 3-10.

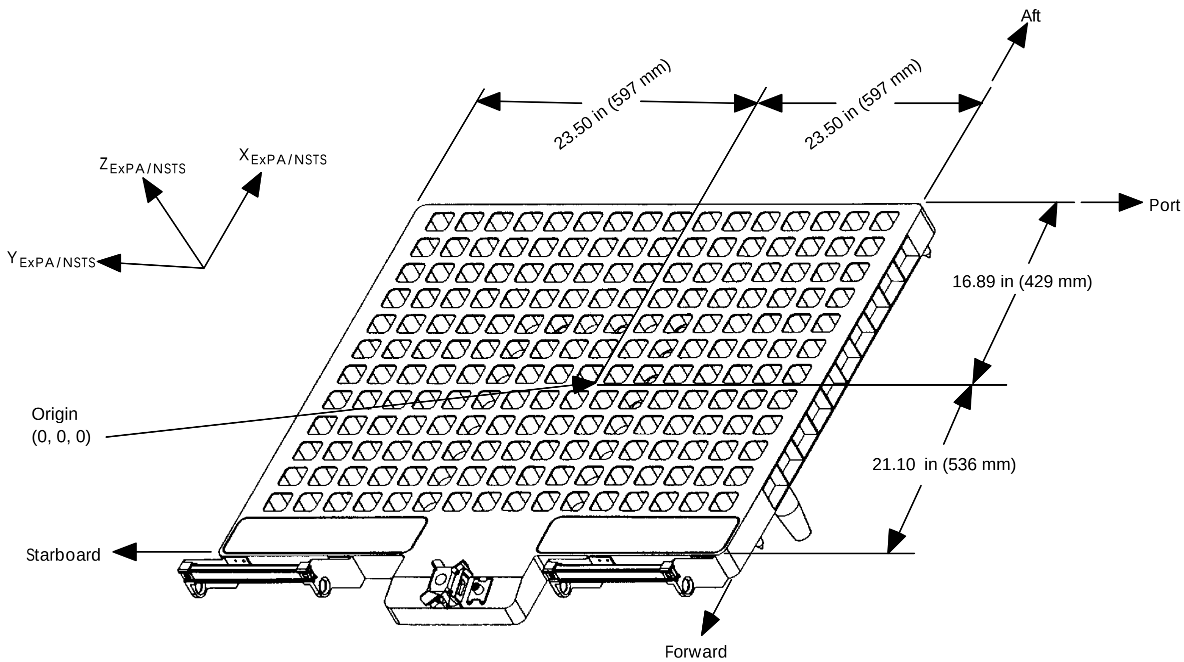
3.1.5 Sidewall Carrier Coordinate System

The Sidewall Carrier structural coordinate system is shown in Figure 3-11.

3.2 DIMENSIONS AND TOLERANCES

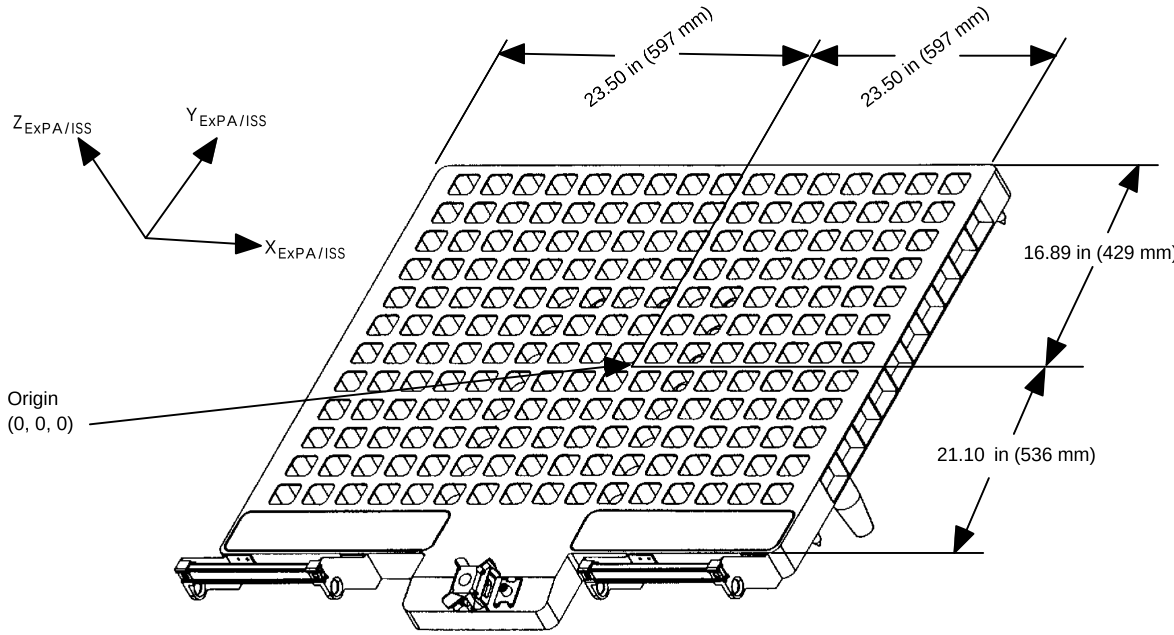
Unless otherwise specified, all linear dimensions are in inches, all angular dimensions are in degrees, and the tolerances for these are as follows:

Decimal:	X.X	= ±0.1
	X.XX	= ±0.03
	X.XXX	= ±0.010
Fractions:		±1/16
Angles:		$\pm 0^{0}$ 30’



NAME:	ExPA Launch Coordinate System
TYPE:	Rotating Right-Handed Cartesian, Body-Fixed
DESCRIPTION:	The ExPA will be attached to the ExP so that the coordinate axes are nominally parallel to each other and the Space Shuttle orbiter axes X_O, Y_O, and Z_O.
ORIGIN:	The origin is located at the center of the payload envelope on the X-Y plane of the ExPA.
ORIENTATION:	$X_{ExPA/NSTS}$ The X-axis is parallel to the Space Shuttle orbiter X_O-axis and positive away from the connector panel side of the ExPA.
	$Y_{ExPA/NSTS}$ The Y-axis is parallel to the Space Shuttle orbiter Y_O-axis and positive toward the starboard side of the Space Shuttle orbiter in the forward position on the ExP.
	$Z_{ExPA/NSTS}$ The Z-axis is parallel to the Space Shuttle orbiter Z_O-axis and positive upward in the landing attitude.
SUBSCRIPT:	ExPA/NSTS

FIGURE 3-6 EXPA LAUNCH COORDINATE SYSTEM (TBC)



NAME: ExPA On-orbit Coordinate System

TYPE: Rotating Right-Handed Cartesian, Body-Fixed

DESCRIPTION: The ExPA will be attached to the ExP so that the coordinate axes are nominally parallel to each other and the Space Shuttle orbiter axes X_R, Y_R, and Z_R.

ORIGIN: The origin is located at the center of the payload envelope on the X-Y plane of the ExPA.

ORIENTATION: $X_{ExPA/ISS}$ The X-axis is parallel to the Space Station X_R-axis and positive in the direction of flight when attached to the Space Station.

$Y_{ExPA/ISS}$ The Y-axis is parallel to the Space Station Y_R-axis and positive away from the connector panel side of the ExP.

$Z_{ExPA/ISS}$ The Z-axis is parallel to the Space Station Z_R-axis and positive toward nadir when the ExP is attached to the nadir side of the ITS and positive toward zenith when attached to the zenith side of the ITS.

SUBSCRIPT: ExPA/ISS

FIGURE 3-7 EXPA ON-ORBIT COORDINATE SYSTEM (TBC)

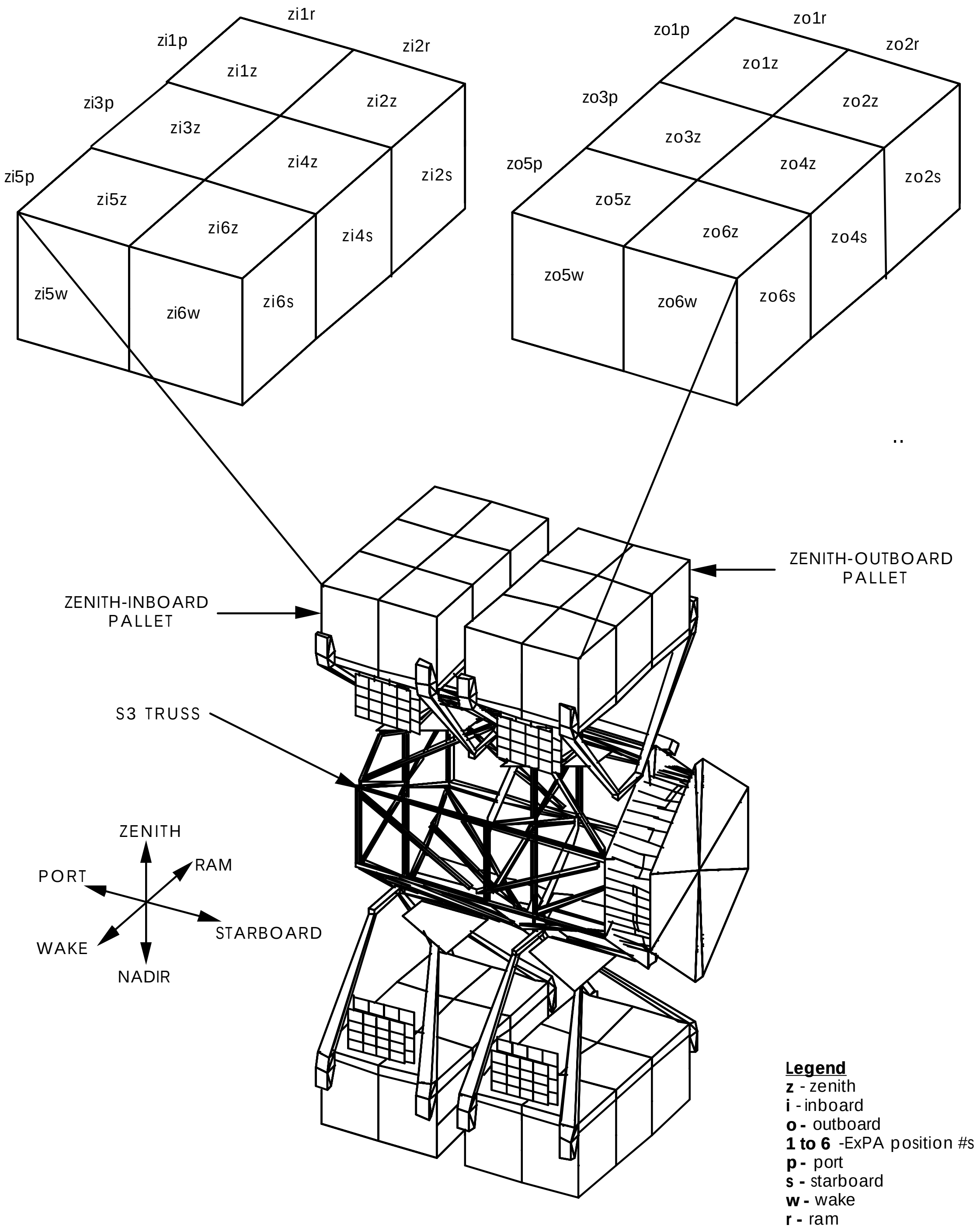


FIGURE 3-8 EXP ISS NOMENCLATURE (ZENITH PAYLOADS)

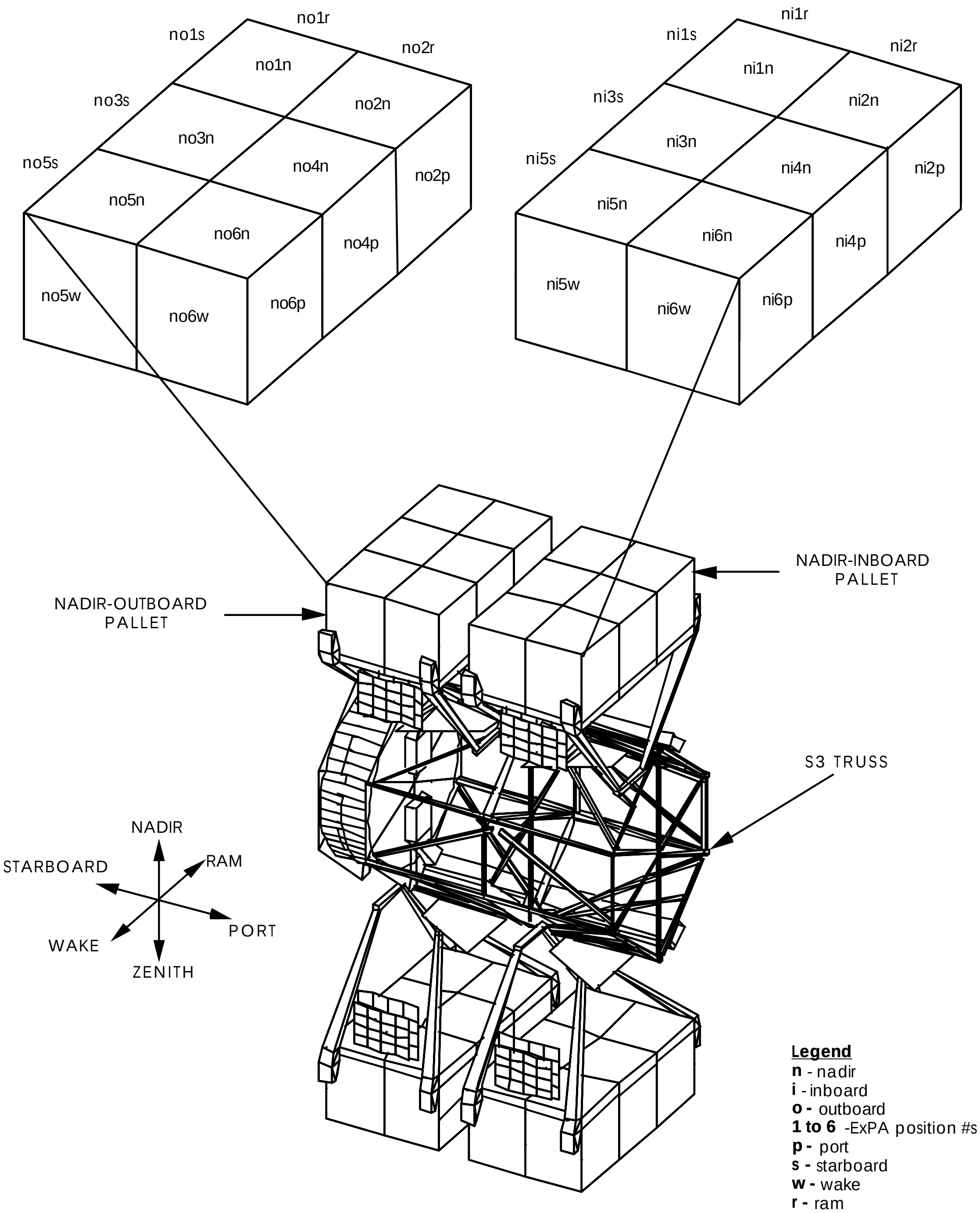


FIGURE 3-9 EXP ISS NOMENCLATURE (NADIR PAYLOADS)

TBD#3-01

FIGURE 3-10 ULC STRUCTURAL COORDINATE SYSTEM

TBD#3-02

FIGURE 3-11 SIDEWALL CARRIER STRUCTURAL COORDINATE SYSTEM

TABLE 3-I EXP ISS LOCATION NOMENCLATURE CROSS REFERENCE

EXP NOMENCLATURE	ISS ATTACHED PAYLOAD NOMENCLATURE
Nadir Inboard	S3, PAS 4
Nadir Outboard	S3, PAS 3
Zenith Inboard	S3, PAS 2
Zenith Outboard	S3, PAS 1

PAS – Payload Attach System

A coordinate system cross reference for ExP on ISS is shown in Table 3-II. The coordinates shown in Table 3-II are consistent with JSC 26557, ISS On-Orbit, Assembly, Modeling, and Mass Properties Data Book.

3.3 MECHANICAL INTERFACES

3.3.1 EXPRESS Pallet Adapter

ExP payloads are mounted to an ExPA. Up to six ExPAs can be mounted on an ExP. The ExPA is the only payload accommodation method for ExP. The ExPA structure is shown in Figure 3-12.

3.4 MECHANICAL PAYLOAD PROVISIONS

3.4.1 Payload Mounting Provisions

Payload mounting provisions consist of standard ExPAs. The ISS Program will provide ExPAs to PDs. The payload shall be compatible with the mechanical interfaces shown in Figure 3-13.

The bolt hole pattern is defined in Figure 3-13. The ExPA bolt hole is designed to accommodate ¼ inch, 28, fine thread fasteners. Each payload must provide its own fasteners.

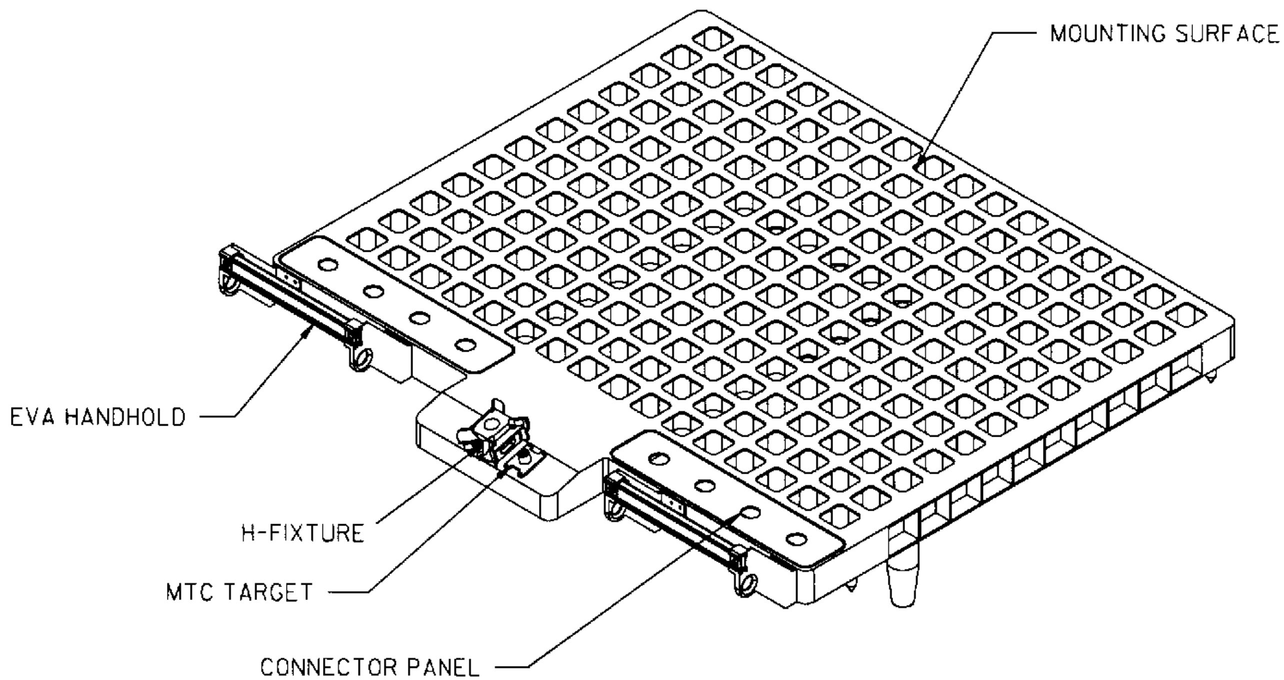
Figure 3-14 shows the payload-to-ExPA attach point details.

3.4.2 Connector Panel Interfaces Provisions

The details of the electrical and data connector panels on the ExPA are as shown in Figures 3-15 and 3-16.

TABLE 3-II COORDINATE SYSTEM CROSS REFERENCE FOR EXP ON ISS

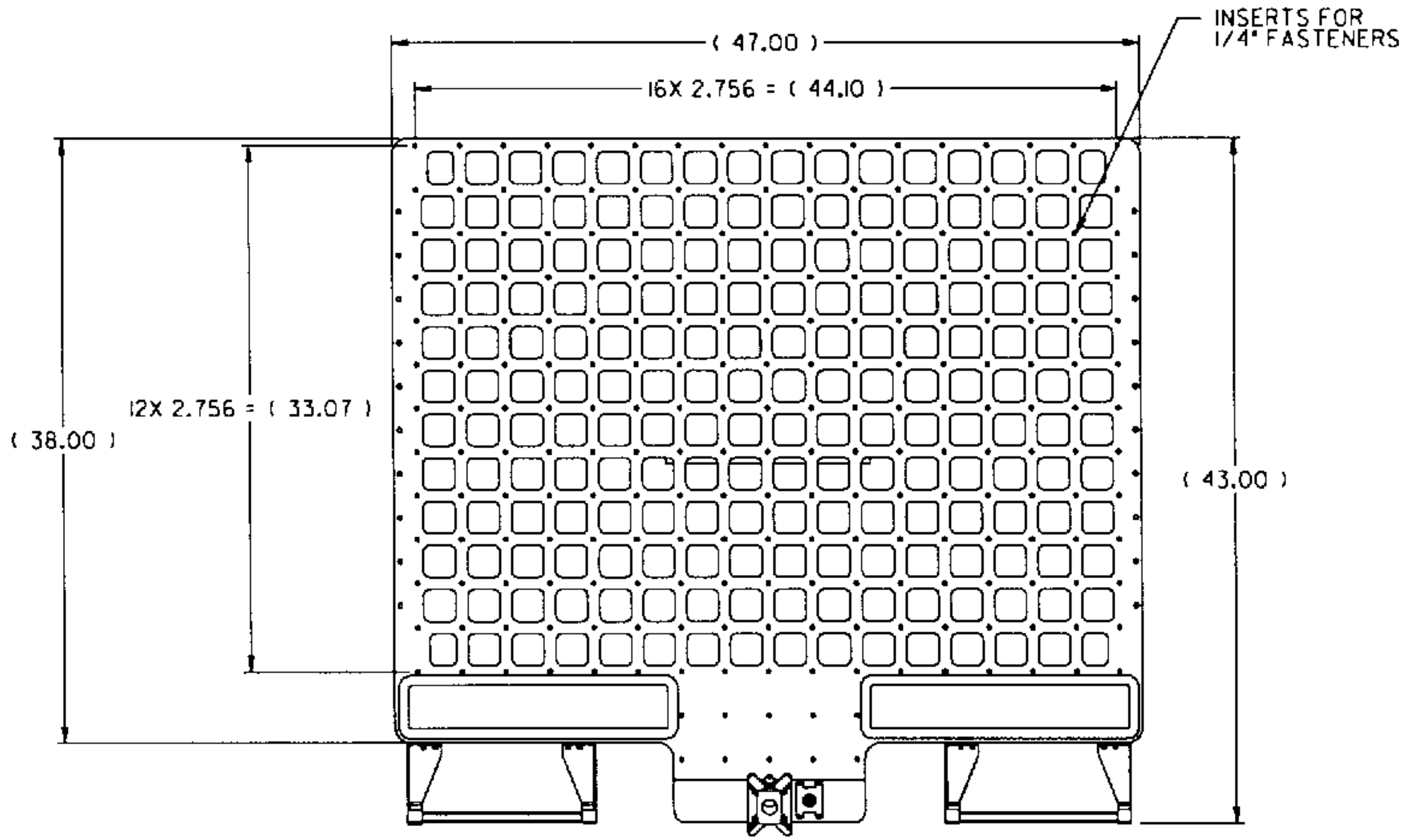
ISS COORDINATE SYSTEM	EXP ISS LOCATION							
	NADIR INBOARD	NADIR INBOARD	NADIR OUTBOARD	NADIR OUTBOARD	ZENITH INBOARD	ZENITH INBOARD	ZENITH OUTBOARD	ZENITH OUTBOARD
	inches	meters	inches	meters	inches	meters	inches	meters
ExP Structural Coordinate System	X_{ExP} = **TBD#3-03** Y_{ExP} = **TBD#3-03** Z_{ExP} = **TBD#3-03**	X_{ExP} = **TBD#3-03** Y_{ExP} = **TBD#3-03** Z_{ExP} = **TBD#3-03**	X_{ExP} = **TBD#3-03** Y_{ExP} = **TBD#3-03** Z_{ExP} = **TBD#3-03**	X_{ExP} = **TBD#3-03** Y_{ExP} = **TBD#3-03** Z_{ExP} = **TBD#3-03**	X_{ExP} = **TBD#3-03** Y_{ExP} = **TBD#3-03** Z_{ExP} = **TBD#3-03**	X_{ExP} = **TBD#3-03** Y_{ExP} = **TBD#3-03** Z_{ExP} = **TBD#3-03**	X_{ExP} = **TBD#3-03** Y_{ExP} = **TBD#3-03** Z_{ExP} = **TBD#3-03**	X_{ExP} = **TBD#3-03** Y_{ExP} = **TBD#3-03** Z_{ExP} = **TBD#3-03**
ITS S3 Coordinate System	$X_{S3} = 2.200$ $Y_{S3} = 169.880$ $Z_{S3} = 79.700$	$X_{S3} = 0.056$ $Y_{S3} = 4.315$ $Z_{S3} = 2.024$	$X_{S3} = 2.200$ $Y_{S3} = 285.260$ $Z_{S3} = 79.700$	$X_{S3} = 0.056$ $Y_{S3} = 7.246$ $Z_{S3} = 2.024$	$X_{S3} = 2.200$ $Y_{S3} = 121.073$ $Z_{S3} = -79.700$	$X_{S3} = 0.056$ $Y_{S3} = 3.075$ $Z_{S3} = -2.024$	$X_{S3} = 2.200$ $Y_{S3} = 234.443$ $Z_{S3} = -79.700$	$X_{S3} = 0.056$ $Y_{S3} = 5.955$ $Z_{S3} = -2.024$
ISS Reference Coordinate System	$X_R = -97.800$ $Y_R = 869.680$ $Z_R = -20.300$	$X_R = -2.484$ $Y_R = 22.090$ $Z_R = -0.516$	$X_R = -97.800$ $Y_R = 985.060$ $Z_R = -20.300$	$X_R = -2.484$ $Y_R = 25.021$ $Z_R = -0.516$	$X_R = -97.800$ $Y_R = 820.873$ $Z_R = -179.700$	$X_R = -2.484$ $Y_R = 20.850$ $Z_R = -4.564$	$X_R = -97.800$ $Y_R = 934.243$ $Z_R = -179.700$	$X_R = -2.484$ $Y_R = 23.730$ $Z_R = -4.564$



NOTES:

1. ExPA Material: Machined **TBD#3-04** Aluminum Alloy
2. Surface Finish: Anodized per MIL-A-8625, Type II, Class I, Hot Water Seal

FIGURE 3-12 EXPA CONFIGURATION (TBC)



NOTE: The ExPA has 2.756 in (70 mm) center-to-center spacing between payload mounting holes.

FIGURE 3-13 EXPA PAYLOAD MOUNTING PROVISIONS (TBC)

TBD#3-05

FIGURE 3-14 PAYLOAD/EXPA ATTACHMENT POINT DETAILS

TBD#3-06

FIGURE 3-15 CONNECTOR PANEL 1 LOCATION AND CONFIGURATION

TBD#3-07

FIGURE 3-16 CONNECTOR PANEL 2 LOCATION AND CONFIGURATION

3.4.3 Fasteners Requirements

3.4.3.1 Captive Fasteners

The fasteners which attach the payload equipment to the ExPA shall be held captive to the payload side of the interface. The captive feature is required for any planned on-orbit transfer activity.

3.4.3.2 Securing of Threaded Fasteners

All payload structural and mechanical system fasteners shall (1) use a means of positive locking as specified in MSFC-STD-561. For non-fracture-critical fasteners, cotter pins, safety wires, safety cables, thread-locking compound, locking nuts, locking inserts, or equivalent may be used to satisfy this requirement. All safety-critical structural fasteners shall (2) be torqued in accordance with MSFC-STD-486 and analyzed to the requirements in NSTS 08307.

Design Guidance**:** Drawings should clearly depict the safety wiring or safety cable method and configuration used (per NASM 33540 as applicable). Reference paragraph 3.6.2 for disposition of sharp edges. Threaded inserts should be used in applications that require tapped holes in aluminum, magnesium, plastics, or other materials that are susceptible to galling or thread damage. When self-locking features are used, the screw length should be sufficient to fully engage the locking device with a minimum of two thread protrusion through the locking mechanism. When self-locking devices are used, an allowable range of running torque, or the maximum number of reuses that would still ensure an adequate lock, should be specified. Spring-type or star-type lock washers should not be used. Adjustable fittings or mounting plates which use oversized holes or slotted holes to provide adjustment should not be dependent upon friction between the fitting or mounting plate and the mounting surface to provide locking. Diamond-type serrations should not be used. The strength requirements for ExP payload fastener receptacles are shown in Table 3-III.

Design Guidance**:** Threaded fasteners should be high strength corrosion resistant steel alloy (e.g., A286) with ultimate tensile strength in the 125-ksi to 150-ksi range. The use of high strength (>160 ksi) fasteners should be avoided where possible to preclude stress corrosion cracking problems.

3.4.3.3 Fracture-Critical Threaded Fasteners

Fracture-critical threaded fasteners (and threaded fasteners used in an application of retaining a rotating device) shall be safety cabled per SAE AS4536 or cotter pinned per NASM 33540.

Fasteners internal to payload components, which are shown to be contained, are excluded from this requirement.

TABLE 3-III ATTACHMENT BOLT RECEPTACLE FORCE ALLOWABLES FOR EXP

TBD#3-08

3.4.3.4 Redundant Threaded Fasteners Locking Requirements

A. Redundant threaded fasteners (non-fracture critical) shall employ self-locking threaded devices or approved locking compounds per MSFC-STD-561.

B. Self-locking threaded devices shall meet the fastener vibration test requirements of NASM-1312-7.

C. Locking compounds shall be selected such that they meet the outgassing requirements defined in paragraph 13.1.4.

D. Locking compounds shall not be used in areas where excess compound could migrate to surfaces which must remain free to move.

E. Self-locking devices which can generate debris shall be avoided.

F. Fasteners less than 3/16 in (4.8 mm) shall not be used in fracture-critical applications except as noted in paragraph 6.2.5D of SSP 52005.

3.4.4 Payload Mass and CG Capabilities

The ExPS shall accommodate a maximum payload weight of 500 lb (227 kg) at each ExPA location with a CG as shown in Table 4-IV.

3.5 GROUND SUPPORT EQUIPMENT (GSE)

3.5.1 Ground Handling Requirements

Structural and mechanical requirements for payload ground handling at KSC are defined in SSP 52000-PAH-LSP. This document applies primarily to ground deintegration of the ExPA after returning from ISS. Ground processes for ExP payloads are identified in SSP 52000-PAH-EPP.

3.5.2 Ground Handling Payload Attachments

The following information is design guidance only and generally applies to off-line handling of ExP payload hardware prior to turnover of an integrated ExPA.

Design Guidance: Ground handling of hardware without handles, particularly if the items are heavy and bulky, becomes difficult if the items must be stowed at the launch pad. To facilitate this handling process, GSE receptacles (PN MD-122-0012-004) and rivets (PN NAS-1198-4-4) could be incorporated in the user's hardware. A limited supply of GSE receptacles has been stocked by KSC to support PDs as an optional service. These receptacles, shown in Figure 3-17, can be used either with a T-handle or with a single handle. It should be noted that for a single handle, the receptacles must be accurately spaced on the experiment hardware. The handle configuration is shown in Figure 3-17.

3.6 PAYLOAD ENVELOPE REQUIREMENTS

3.6.1 Payload Static Envelopes

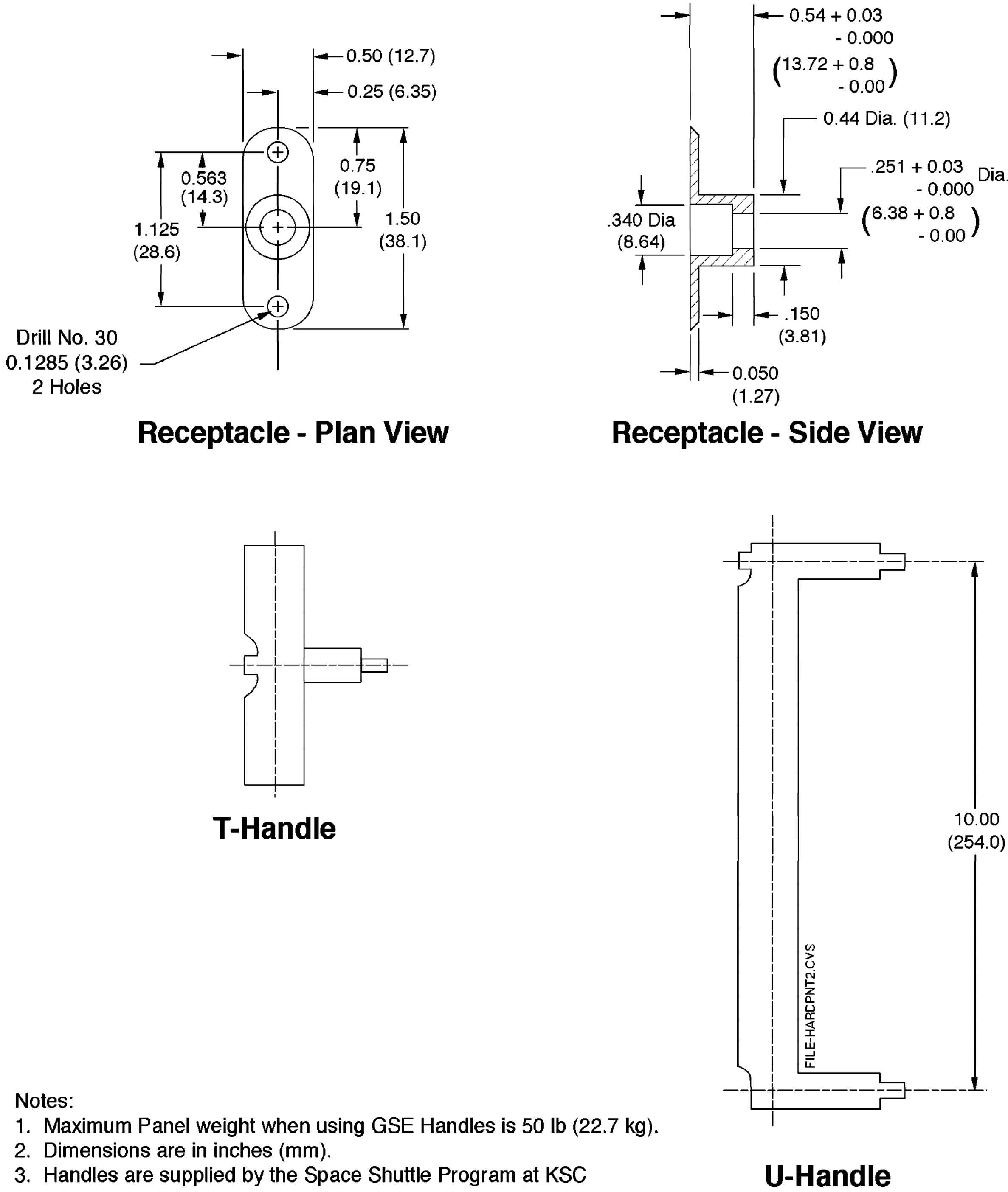
Payload hardware design shall (1) not violate the static envelope dimensions shown in Figures 3-18 and 3-19. Payload hardware, including fasteners, shall (2) not protrude below the ExPA bottom surface.

Protrusions outside the payload envelope must be approved by the ISS Program.

The payload envelope dimensions and coordinates are shown in Table 3-IV.

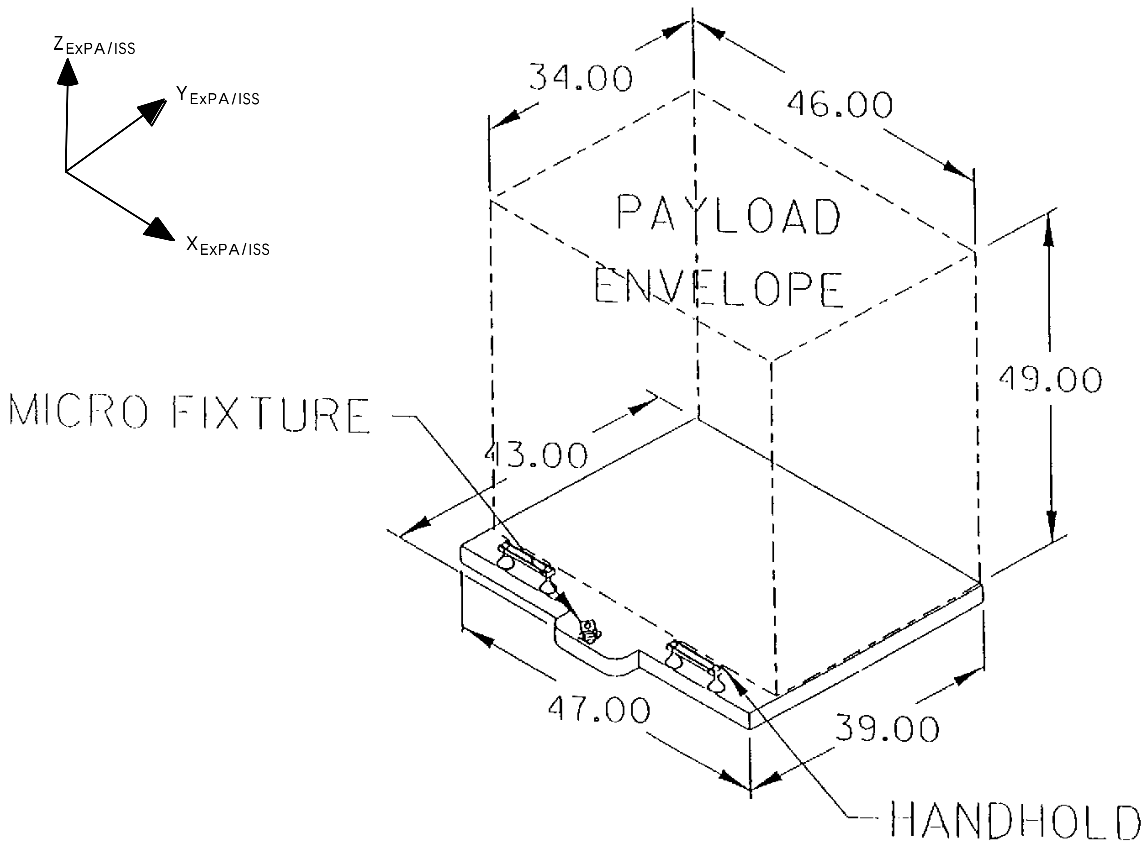
3.6.2 Sharp Edges and Corners

The requirements in paragraphs 3.6.2.1, 3.6.2.2, and 3.6.2.3 are applicable to hardware exposed to the crew during Extra Vehicular Activity (EVA). The requirements in this section are consistent with SSP 50005, ISS Flight Crew Integration Standard, paragraph 6.3.3.1.



Notes:
1. Maximum Panel weight when using GSE Handles is 50 lb (22.7 kg).
2. Dimensions are in inches (mm).
3. Handles are supplied by the Space Shuttle Program at KSC

FIGURE 3-17 PAYLOAD/GSE HARDPOINTS



NOTE: Dimensions are in inches.

FIGURE 3-18 PAYLOAD ENVELOPE FOR EXPA-MOUNTED PAYLOADS (TBC)

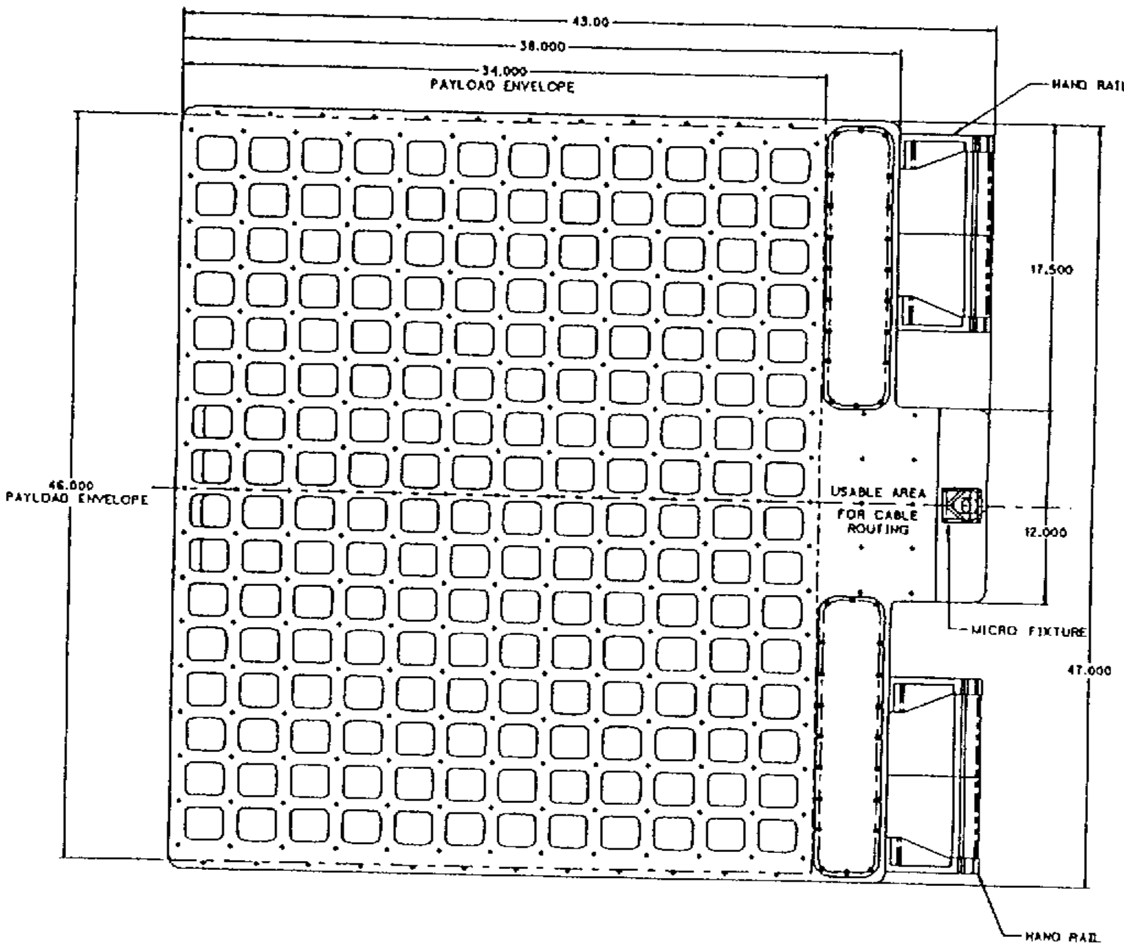


FIGURE 3-19 PAYLOAD ENVELOPE LOCATION ON EXPA (TBC)

TABLE 3-IV EXP PAYLOAD ENVELOPE COORDINATES (TBC)

EXPA COORDINATES[1]	TOTAL DIMENSIONS
$X_{ExPA/ISS}$ = +/- 23.0 in (+/- 584 mm)	Width = 46.0 in (1168 mm)
$Y_{ExPA/ISS}$ = +/- 17.0 in (+/- 432 mm)	Depth = 34.0 in (864 mm)
$Z_{ExPA/ISS}$ = + 49.0 in (+ 1245 mm)	Height = 49.0 in (1245 mm)

NOTE:

1. Reference Figure 3-7.

3.6.2.1 Exposed Edge Requirements (Mounted Hardware)

A. Exposed edges 0.25 in (6.4 mm) thick or greater shall be rounded to a minimum radius of 0.12 in (3.0 mm). See Figure 3-20.

B. Exposed edges 0.12 to 0.25 in (3.0 to 6.4 mm) thick shall be rounded to a minimum radius of 0.06 in (1.5 mm). See Figure 3-21.

C. Exposed edges 0.02 to 0.12 in (0.5 to 3.0 mm) thick shall be rounded to a full radius. See Figure 3-22.

D. The edges of thin sheets less than 0.02 in (0.5 mm) thick shall be rolled or curled. See Figure 3-23.

3.6.2.2 Exposed Corner Requirements (Mounted Hardware)

A. Exposed corners of materials less than 1.0 in (25 mm) thick shall be rounded to a minimum radius of 0.5 in (13 mm). See Figure 3-24.

B. Exposed corners of materials which exceed 1.0 in (25 mm) in thickness shall be rounded to 0.5 in (13 mm) spherical radius. See Figure 3-25.

3.6.2.3 Protective Covers/Shields

Equipment (mounted, portable, loose, or accessible during maintenance operations) which does not meet the corner and edge requirements of 3.6.2.1 or 3.6.2.2 shall be covered or shielded.

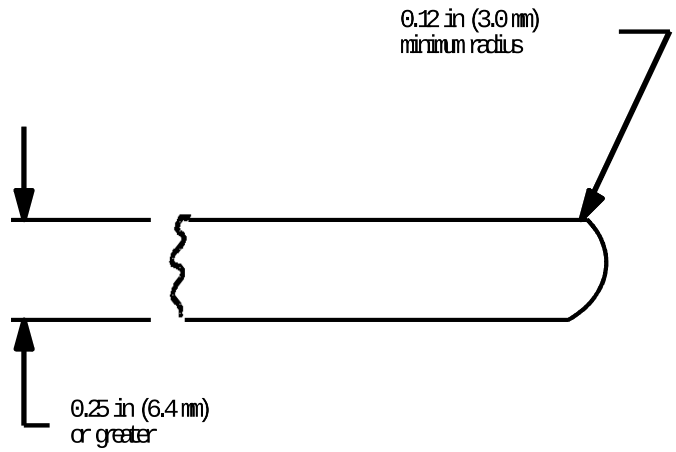


FIGURE 3-20 REQUIREMENTS FOR ROUNDING EXPOSED EDGES 0.25 IN (6.4 MM) THICK OR THICKER

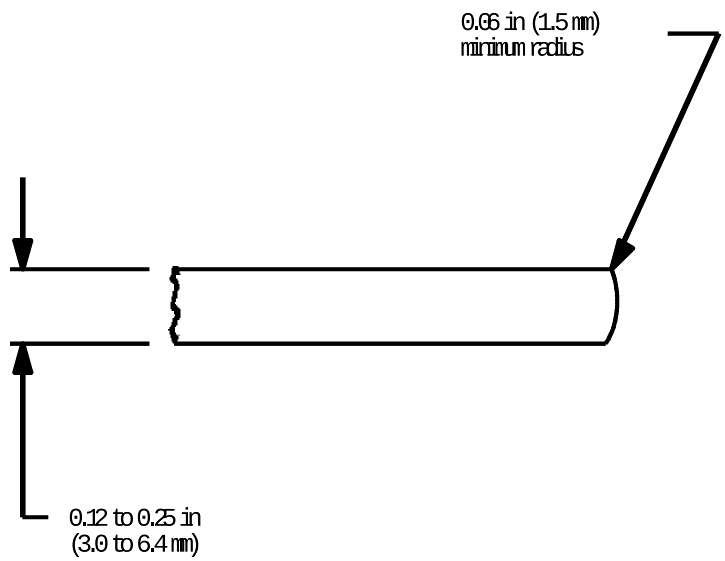


FIGURE 3-21 REQUIREMENTS FOR ROUNDING EXPOSED EDGES 0.12 TO 0.25 IN (3.0 TO 6.4 MM) THICK

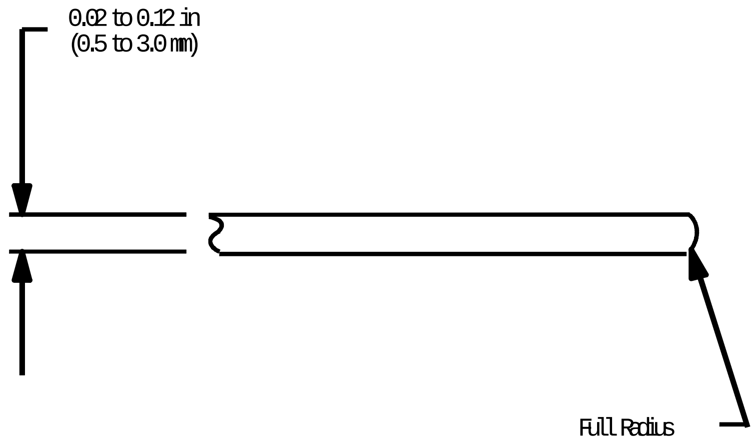


FIGURE 3-22 REQUIREMENTS FOR ROUNDING EXPOSED EDGES 0.02 TO 0.12 IN (0.5 TO 3.0 MM) THICK

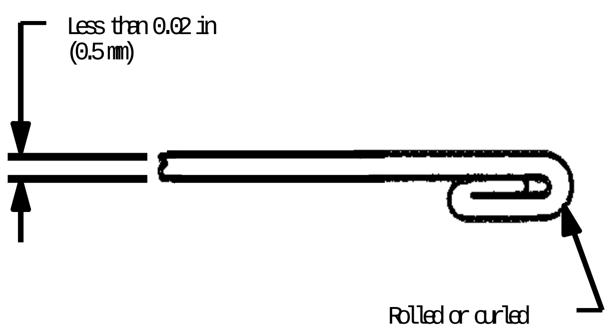


FIGURE 3-23 REQUIREMENTS FOR CURLING OF SHEETS LESS THAN 0.02 IN (0.5 MM) THICK

3.6.2.4 Holes

Holes that are round or slotted in the range of 0.4 to 1.0 in (10.0 to 25.0 mm) shall be covered to prevent crew exposure to sharp surfaces and to prevent debris from entering the hole.

3.6.2.5 Screws/Bolts Ends

Threaded ends of screws and bolts accessible by the crew and extending more than 0.12 in (3.0 mm) shall be covered or capped to protect against sharp threads.

3.6.2.6 Burrs

Exposed surfaces shall be free of burrs.

3.6.2.7 Latches

Latches that pivot, retract, or flex so that a gap of less than 1.4 in (35 mm) exists shall be designed to prevent entrapment of a crewmember's fingers or hand.

3.6.2.8 Levers, Cranks, Hooks, and Controls

Levers, cranks, hooks, and controls shall not be located or oriented such that they can pinch, snag, or cut the crewmember.

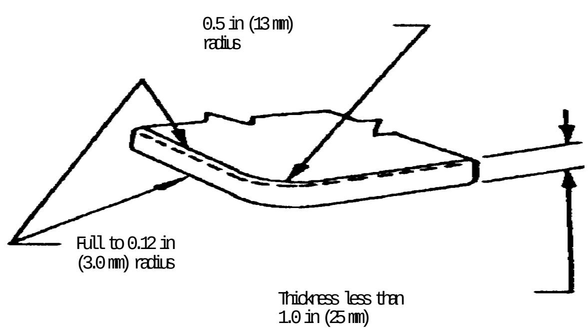


FIGURE 3-24 REQUIREMENTS FOR ROUNDING OF CORNERS LESS THAN 1.0 IN (25 MM) THICK

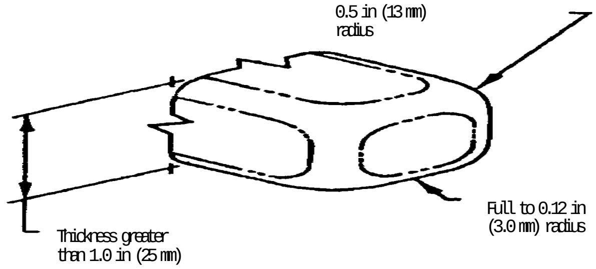


FIGURE 3-25 REQUIREMENTS FOR ROUNDING OF CORNERS GREATER THAN 1.0 IN (25 MM) THICK

3.6.2.9 Safety/Lockwire

Safety cables or lockwire shall not be used on fasteners exposed to the crew except as required by SSP 52005, paragraph 5.6.

3.6.2.10 Securing Pins

Securing pins shall be designed to prevent their inadvertently backing out above the handhold surface.

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SECTION 4, STRUCTURAL INTERFACES

4.1 INTRODUCTION

Structural interface loads for ExP and similar pallet-type carriers (e.g., ULC, etc.) are calculated via application of design load factors to structural weights at the component and/or Pallet structure centers of gravity. The load factors, applied either simultaneously or independently as indicated, represent multiples of gravity. The product of a given directional load factor and the component weight is an applied inertial force in that direction at the appropriate center of gravity location. The sum total of all inertial forces on a given payload for a given design condition represents the input loads to be transferred to the carrier interface in the form of interface shear, moment, and axial load reactions.

Load cases to be examined include Launch and Landing/Emergency Landing (Quasi-Static and Random Vibration), and EVA induced on-orbit loads. Thermal effects are especially important in the on-orbit configuration. The effects of thermally induced loads from differential thermal expansion/contraction must be combined with induced static and dynamic loads in evaluating Pallet structural integrity.

Until the overall ISS attached payload carrier missions are better defined, the quasi-static and random vibration load factors developed in the following sections are to be applied to all Pallet-mounted equipment and carriers. Specific loads for certain carriers (ULC, Sidewall Carrier, etc.) will be added as the design matures.

4.2 OPERATIONAL LOADS

4.2.1 Component Frequency

ExP-mounted equipment shall (1) have a first primary natural frequency greater than 35 Hz during launch and landing phases. Evaluation of this requirement shall (2) be based on rigidly mounting the component at the component-to-adapter plate interface. “Component” refers to an integrated item. This requirement is applicable to the payload without the ExPA.

4.2.2 Payload Low Frequency Launch and Landing Loads

Payload hardware shall be designed to maintain positive margins of safety during lift-off and landing events. The low frequency transient preliminary design load factors for ExP-mounted components are shown in Table 4-I. The methodology for combining loads and evaluating lift-off and landing events is defined in SSP 52005, paragraphs 4.1.2 and 4.1.3.

TABLE 4-I EXP COMPONENT CENTER OF GRAVITY PRELIMINARY DESIGN LOAD FACTORS[1, 2, 3]

LOAD FACTOR DIRECTION	LIFT-OFF (g's)	LANDING (g's)
X	±6.6	±7.9
Y	±4.2	±5.9
Z	±5.0	+6.3/-8.3

NOTES:

1. Load factors apply concurrently in all possible combinations for each event and are shown in the Orbiter Coordinate System, Figure 4-1.
2. Load factors are equal in magnitude and opposite in direction from acceleration.
3. These load factors are to be used for preliminary design only. As the ExP design matures and coupled loads analyses are performed, these load factors will be superseded.

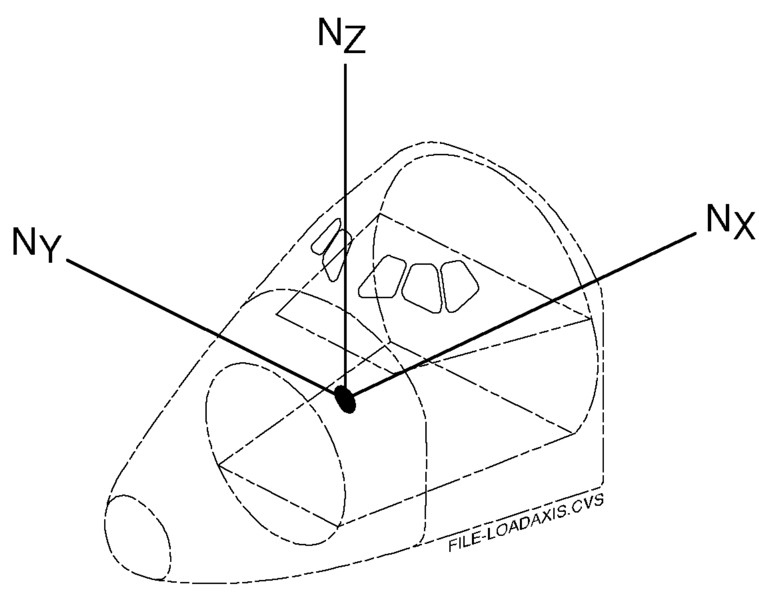


FIGURE 4-1 DIRECTIONS OF LOAD FACTORS

A load factor represents the inertial force resulting from a given acceleration, and is therefore equal in magnitude and opposite in direction from that acceleration.

4.3 EMERGENCY LANDING LOAD FACTORS

These load factors are presented below and shall be used for hardware landing in the Shuttle cargo bay.

Load factors associated with emergency landing events for payload hardware flown in the Shuttle cargo bay are defined in Table 4-II.

TABLE 4-II EMERGENCY LANDING LOAD FACTORS[1, 2, 3, 4]

ULTIMATE INERTIA LOAD FACTORS		
Nx	Ny	Nz
$\pm$4.5	$\pm$1.5	+2.0/-4.5

NOTES:

1. Sign convention follows that of the orbiter coordinate system.
2. Emergency landing load factors are ultimate.
3. The specified load factors will operate independently.
4. Load factors are equal in magnitude and opposite in direction from acceleration.

4.4 RANDOM VIBRATION

The random vibration environment for components mounted to ExP adapter plates is shown in Table 4-III.

4.5 EXP ADAPTER PLATE INTERFACE LOADS

The weight-to-CG relationship for payloads attached to the ExP adapter plate shall conform to Table 4-IV. The maximum weight of ExPA-mounted payloads is 500 lb (226.8 kg).

4.6 ON-ORBIT LOADS

ExP payloads shall be designed to be safe in the applicable worst-case nature and induced on-orbit environments as specified in SSP 30425, for the on-orbit acceleration, vibration and shock (plume impingement) environments.

TABLE 4-III HIGH FREQUENCY RANDOM VIBRATION ENVIRONMENT FOR EXP PAYLOAD EQUIPMENT DESIGN[1] (TBC)

EQUIPMENT	FREQUENCY	LEVEL
Component weight <110 lb (50 kg) (all directions)	20 Hz	0.01 g^2/Hz
	20 – 165 Hz	+3 dB/oct
	165 – 250 Hz	0.08 g^2/Hz
	250 – 2000 Hz	-3 dB/oct
	2000 Hz	0.01 g^2/Hz
	Composite	7.4 g_{rms}
Component weight $\geq$110 lb (50 kg) but <200 lb (91 kg) (all directions)	20 Hz	0.01 g^2/Hz
	20 – 80 Hz	+3 dB/oct
	80 – 500 Hz	0.04 g^2/Hz
	500 – 2000 Hz	-3 dB/oct
	2000 Hz	0.01 g^2/Hz
	Composite	6.8 g_{rms}
Component weight $\geq$200 lb (91 kg) but <400 lb (182 kg) (all directions)	20 Hz	0.0071 g^2/Hz
	20 – 80 Hz	+3 dB/oct
	80 – 500 Hz	0.029 g^2/Hz
	500 – 2000 Hz	-3 dB/oct
	2000 Hz	0.0071 g^2/Hz
	Composite	5.7 g_{rms}
Component weight $\geq$400 lb (182 kg) but <500 lb (227 kg) (all directions)	20 Hz	0.0051 g^2/Hz
	20 – 80 Hz	+3 dB/oct
	80 – 500 Hz	0.02 g^2/Hz
	500 – 2000 Hz	-3 dB/oct
	2000 Hz	0.0051 g^2/Hz
	Composite	4.8 g_{rms}

Legend:
dB = decibel = 10 log (W/W_o), sound power level, W, referenced to $W_o = 10^{-12}$ W
g_{rms} = gravity (g), root mean square
oct = octave

NOTE:

1. This environment is to be used for preliminary design only. As the ExP design matures, this environment will be revised to reflect results of development testing and final design.

TABLE 4-IV PAYLOAD CG REQUIREMENTS[1]

PAYLOAD MASS (lb) [kg]	MAXIMUM DEVIATION FROM GEOMETRIC CENTER IN $X_{ExPA/NSTS}$ – $Y_{ExPA/NSTS}$ PLANE (in) [mm]	MAXIMUM HEIGHT ($Z_{ExPA/NSTS}$) OF PAYLOAD CENTER OF GRAVITY (CG) ABOVE THE EXPA MOUNTING PLANE (in) [mm]
401 – 500 [181.9 – 226.8]	$\Delta X_{ExPA/NSTS}$ = 7.5 [190], $\Delta Y_{ExPA/NSTS}$ = 7.5 [190]	19.5 [495]
301 – 400 [136.5 – 181.4]	$\Delta X_{ExPA/NSTS}$ = 9 [229], $\Delta Y_{ExPA/NSTS}$ = 10 [254]	24.0 [610]
201 – 300 [91.2 – 136.1]	$\Delta X_{ExPA/NSTS}$ = 10.5 [267], $\Delta Y_{ExPA/NSTS}$ = 12 [305]	28.0 [711]
<200 [<90.7]	$\Delta X_{ExPA/NSTS}$ = 12 [305], $\Delta Y_{ExPA/NSTS}$ = 14 [356]	30.0 [762]

NOTE:

1. Reference Figure 3-6.

4.6.1 Payload Berthing

TBD#4-01

4.6.2 Reboost

TBD#4-02

4.6.3 Payload-Induced Operational Loads

TBD#4-03

4.6.4 Thermal Effects

ExP payload structure shall meet interface requirements specified herein when applicable thermal effects as described in paragraph 5.3.4 are combined with induced static and dynamics loads, including thermally induced structural interface loads.

4.6.5 External Induced Loads

4.6.5.1 EVA On-Orbit Induced Loads

EVA on-orbit induced loads for inadvertent kick and kick-off, push-off loads do not apply to hardware or worksites which are assembled or maintained using robotic systems. Contingency EVA activities associated with attached payloads will be performed by a crewmember restrained on the Space Station Remote Manipulator System (SSRMS), except for the case noted below.

The payload structure shall support the limit loads induced by an EVA crewmember provided in Table 4-V, during contingency operations associated with robotics removal from a grapple fixture.

4.6.5.2 EVR On-Orbit Induced Loads

TBD#4-04

4.6.5.2.1 Shuttle Remote Manipulator System (SRMS) On-Orbit Induced Loads

TBD#4-05

4.6.5.2.2 SSRMS On-Orbit Induced Loads

TBD#4-06

4.6.5.2.3 Special Purpose Dextrous Manipulator (SPDM) On-Orbit Induced Loads

TBD#4-07

4.6.5.3 Subsequent Induced Loads

If an ExP payload is deployed, extended, or otherwise unstowed to a condition where it cannot withstand subsequent induced loads, there shall be one- or two-failure tolerant design provisions to safe the component to the appropriate hazard level. Safing may include deployment or provisions to change the configuration of the component to eliminate the hazard.

4.7 EXP PAYLOAD STRUCTURAL DESIGN

4.7.1 Structural Design

ExP payload structural design and verification, including glass, window, and ceramic structures, shall (1) be in accordance with the requirements specified in NSTS 1700.7 and ISS Addendum, NSTS 18798, and SSP 52005 for safety-critical structures. The PD shall (2) ensure that positive margins of safety are maintained for all mission phases. An evaluation must be prepared by the PD to document all discrepancies between the design drawings and the as- built flight hardware. These discrepancies must be evaluated for impacts to the structural, mechanical, and dynamic analyses and/or tests. The PD shall (3) update these

TABLE 4-V EVA-INDUCED LOADS

DESIGN LIMIT LOAD TYPE	LIMIT LOAD	TYPE OF LOADING	DIRECTION	CATEGORY OF STRUCTURE	APPLICATION COMMENTS
Inadvertent Kick, Bump Any Direction	125 lbf	Quasi-static, concentrated load over a 0.5-in diameter circular area	Any direction	Secondary structure near (within 24 in) translation path or worksite	This is an accidental impact. It should be applied to hardware near (within 24 in) translation paths and worksites.

NOTE: EVA on-orbit induced loads for inadvertent kick and kick-off, push-off loads do not apply to hardware or worksites which are assembled or maintained using robotic systems (crewmember restrained on SRMS or SSRMS).

analyses and perform these tests as required to reverify the structural integrity if the change warrants. The Pallet integrator must be contacted to discuss the impacts of these changes for any analyses updates or retesting.

4.7.2 Fracture Control

Payload structural components, including all pressure vessels, the failure of which would cause damage to the orbiter, damage to the ISS, or injury to personnel, shall (1) be analyzed to preclude failures caused by propagation of pre-existing flaws. Fracture control documentation of critical structural components shall (2) be processed by the PD in accordance with NSTS 1700.7 and its ISS Addendum, NSTS 13830, NSTS 18798 (including JSC Letter TA94-057, "Modified Fracture Control Criteria and Guidelines for Payloads"), NASA-STD-5003, and SSP 52005 during the payload safety review process.

4.8 LIFT-OFF AND ASCENT ACOUSTICS

Equipment and payloads mounted on the ExP shall be designed to withstand the Sound Pressure Levels (SPL) specified in NSTS 21000-IDD-ISS, paragraph 4.1.1.5.

4.9 DEPRESSURIZATION/REPRESSURIZATION REQUIREMENTS

Payload structures containing enclosed volumes shall maintain positive margins of safety per NSTS 1700.7 and ISS Addendum, NSTS 18798, and SSP 52005 when exposed to the worst-case depressurization/repressurization environments defined in NSTS 21000-IDD-ISS, paragraph 10.6.1.

4.10 GROUND HANDLING ENVIRONMENTS

Flight hardware which (1) will be shipped in a PD-provided shipping container and (2) has the potential to create a flight safety hazard if damaged during ground transportation (including fracture-critical parts or components) shall be evaluated for their applicable ground transportation events in accordance with the following paragraphs.

Design Guidance: Flight hardware should not experience loads which exceed 80% of the flight environments during ground handling operations. Shipping containers should be designed to ensure that this limitation is maintained.

4.10.1 Ground Handling Load Factors

Payloads which are packaged for ground handling events in PD-provided shipping containers and have the potential to create a flight safety hazard if damaged during handling and transportation (including fracture-critical parts or components) shall be analyzed in accordance with SSP 52005 using the transportation limit load factors defined in Table 4-VI (for typical operations). These analyses shall evaluate the flight hardware when mounted in the shipping container in appropriate configurations.

TABLE 4-VI LIMIT LOAD FACTORS (g) FOR GROUND-HANDLING, ROAD, AIR, AND BARGE OPERATIONS

TRANSPORTATION ENVIRONMENT	LIMIT LOAD FACTORS (g)[3, 4]			LOAD OCCURRENCE[1]
	LONGITUDINAL[2]	LATERAL	VERTICAL	
Truck/Road	±3.5	±2.0	-3.5/+1.5	I
Barge/Water	±0.5	±2.5	-2.5/+0.5	I
Dolly/Land	±1.0	±0.75	-2.0/+0.0	I
Air Freight	±3.5	±3.5	-3.5/+1.5	I
Forklifting	±1.0	±0.5	-2.0/+0.0	S

NOTES:

1. S = Loads occur simultaneously in the three directions.
   I = Loads occur independently in the three directions (except for gravity).
2. The sign convention is consistent with the Space Shuttle orbiter coordinate system.
3. Longitudinal = Along axis of motion.
4. Load factors are equal in magnitude and opposite in direction from acceleration.

4.10.2 4.10.2 Ground Handling Shock Criteria

Payloads which are packaged for ground handling events in PD-provided shipping containers and have the potential to create a flight safety hazard if damaged during handling and transportation (including fracture-critical parts or components) shall be analyzed in accordance with SSP 52005, and the payload shall be designed to maintain positive margins of safety when exposed to the drop requirements defined in FED-STD-101, Methods 5005.1, 5007.1, or 5008.1.

In lieu of this federal standard, the PD may choose to evaluate the payload using a shock environment represented by 20-g sawtooth shock pulses (having a 10-ms duration along both directions of each of three orthogonal axes) for evaluations of the payload hardware.

All of these analyses shall evaluate the flight hardware when mounted in the shipping container in appropriate configurations.

4.11 MICROGRAVITY DISTURBANCES

Microgravity allocations to ExP payloads have not been established and are pending Pallet subsystem verification.

4.11.1 Quiescent Period Payload-Induced Quasi-Steady Accelerations

ExP payloads shall meet the TBD#4-08 quasi-steady disturbance requirement.

4.11.2 Quiescent Period Payload-Induced Transient Accelerations

ExP payloads shall meet the TBD#4-09 transient disturbance requirement.

Design Guidance: This limit is applied to each disturbance source in the payload.

4.11.3 On-Orbit Vibration - Quiescent Periods

ExP payloads shall limit vibroacoustic disturbances to **TBD#4-10**.

SECTION 5, THERMAL INTERFACE

5.1 INTRODUCTION

This section describes the thermal interfaces for ExP and payloads. Thermal requirements for ULC and Sidewall Carrier will be defined as they become available.

5.2 EXP THERMAL CONTROL

5.2.1 Thermal Control

The ExP will not provide any active thermal control. Each ExP payload is responsible for its own thermal control. The ExPA shall not be used as a heat sink. All payload heat rejection requirements shall be met only by radiation to its environment. ExP payloads will not employ thermal control methods which reject heat to neighboring payloads. A discussion of the viewing environment from the ExP including view obstructions adjacent to the ExPAs is provided in Section 14.

5.3 GENERAL REQUIREMENTS

5.3.1 EVA Touch Temperatures

For crew protection, ExP payload surfaces accessible to crew touch shall be maintained within -180 to +235 °F.

5.3.2 Payload Heat Conduction to ExPA

ExP payloads shall have a total conductive heat load of no greater than 50 W for each ExPA.

5.3.3 ISS Thermal Radiation Requirements

Specularity of exposed surfaces of ExP payloads shall be kept to less than 10 percent to prevent damage or interference with the science objectives of other payloads on the ISS.

Specularity is the fraction of radiation striking a surface in which the angle of incidence is equal to the angle of reflection.

5.3.4 Attached Payload-Induced Thermal Effects

TBD#5-01

5.3.5 Mating Thermal Differential

TBD#5-02

5.4 EXP THERMAL ENVIRONMENT DEFINITION

5.4.1 Environmental Conditions

The ground and flight environments the ExP payload can be exposed to are listed in Table 5-I.

TABLE 5-I EXP PAYLOAD ENVIRONMENTAL CONDITIONS

Temperature	**Temperature**
Ground Handling and Transportation	-55 °F to + 160 °F
Prelaunch/Postflight/Storage	0 °F to 100 °F
Ascent and Descent	-55 °F to +150 °F
On-Orbit Environment	**On-Orbit Environment**
Solar Radiation	1321 to 1423 W/m^2
Earth Albedo	20% to 40% of the solar radiation
Earth Radiation	206 to 286.1 W/m^2
Space Soak	0 °K
Ferry Flight Environment	defined in NSTS 21000-IDD-ISS, Sections 10.10.1 and 10.10.2
Pressure	**Pressure**
Prelaunch/Postflight/Storage	15.2 psi maximum
Ascent to Orbit	defined in NSTS 21000-IDD-ISS, Section 10.6
Descent	defined in NSTS 21000-IDD-ISS, Section 10.6
On-Orbit	1.0E-07 torr minimum

5.4.2 ExP-to-ExPA Interface Temperatures

Interface temperatures at the ExPA-to-ExP payload interface are given in Table 5-II.

TABLE 5-II EXPA MAXIMUM AND MINIMUM TEMPERATURES

FLIGHT PHASE	EXPA TEMPERATURE RANGE, °F
Ascent/Descent	-160 to 150
On-Orbit Non-OP (In STS & Translation)	-200 to 150
On-Orbit OP (Stay-Alive) (In STS & Translation)	-200 to 150
On-Orbit OP (On ISS Truss Sites Only)	-160 to 100

5.4.3 ExP Thermal Radiation Environments

Mean Effective Radiation Temperature (MERAT) data is documented for the cases identified in Appendix C. The environmental flux values are provided separately for Earth Infrared (IR) and absorbed Solar.

5.5 ORBITER ENVIRONMENTAL CONTROL INTERFACES

5.5.1 Purge and Vent of Cargo Bay

The orbiter provides a ground purge system, which is comprised of a ground system, supplied, on-board duct network that distributes air/GN_2. A portion of the cargo bay purge flow is lost to the lower mid-fuselage at the vent filters due to the slight cargo bay purge positive pressure.

The cargo bay purge gas characteristics provided by the orbiter to the payload and cargo bay, at the specific prelaunch and post-landing operations phase, are specified in Table 6.2.1.1-1 of NSTS 21000-IDD-ISS.

5.5.2 Trans Atlantic Landing (TAL) and Emergency Landing Site (ELS) Abort Contingency

Provisions for ground purge after landing will be made available within 72 hours in the event of TAL or ELS abort.

5.6 EXP PAYLOAD THERMAL CONTROL RECOMMENDATIONS AND TECHNICAL INFORMATION

TBD#5-03

5.7 ULC THERMAL CONTROL

TBD#5-04

5.8 SIDEWALL CARRIER THERMAL CONTROL

TBD

TBD#5-05

SECTION 6, ELECTRICAL POWER INTERFACES

6.1 INTRODUCTION

This section describes the electrical power interfaces provided by the ExP for payload use. The electrical interfaces provided by the ULC and Sidewall Carriers are **TBD#6-01** and will be defined as interface definitions become available.

6.2 ELECTRICAL POWER INTERFACE DESCRIPTION

6.2.1 On-Orbit/Stay-Alive Power Interface (ExPA Nominal Power Feeds)

The ExP provides two feeds of 120-Vdc power and two feeds of 28-Vdc power to each ExPA during on-orbit (ISS location) and stay-alive (orbiter location, post-ascent) mission phases. The on-orbit/stay-alive power feeds are derived from the ISS or orbiter power sources and distributed to the ExPA locations via the ExPCA. The ExPCA provides for the necessary isolation, switching, and distribution of the ISS or orbiter power provided for payload use. Figure 6-1 provides an overview of the ExP on-orbit/stay-alive power distribution system.

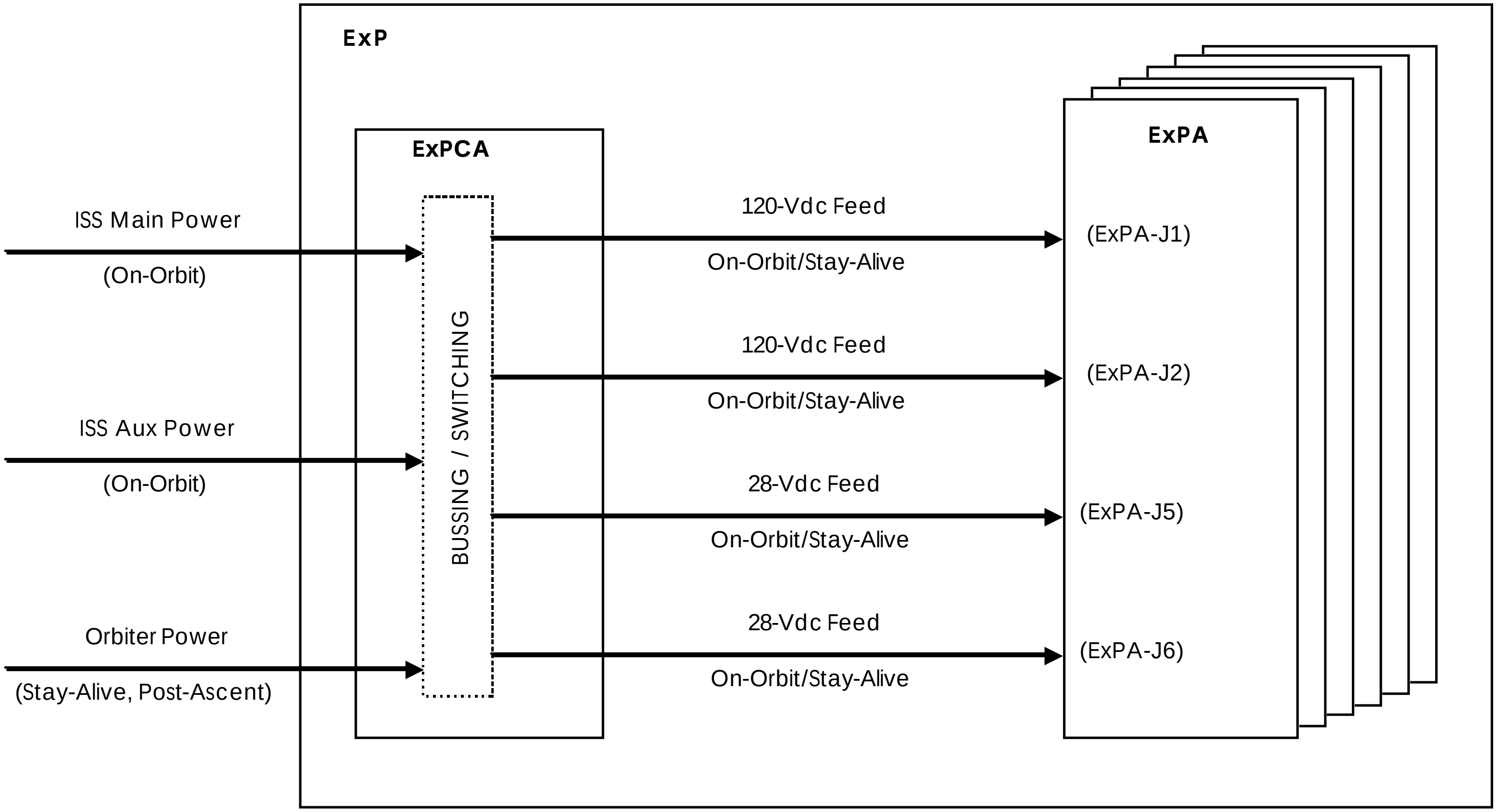
Note: In the remainder of this document section, the terms “output,” “feed,” and “service” are used interchangeably to denote the power service provided by the ExP, for payload use, at the ExPA interface connector panel (reference Figures 3-13 and 3-14).

6.2.2 Emergency Power Interface

The ExP provides two feeds of 120-Vdc emergency power to each ExPA for payload use in the event of an ExPCA catastrophic failure. A catastrophic failure is defined as any failure that renders the ExPCA inoperable and/or unable to control the nominal ExPA power feeds. The emergency power feeds will be supplied directly from, and controlled by, the ISS or orbiter power sources (see Figure 6-2).

6.3 28-VDC OUTPUT CHARACTERISTICS (TBC)

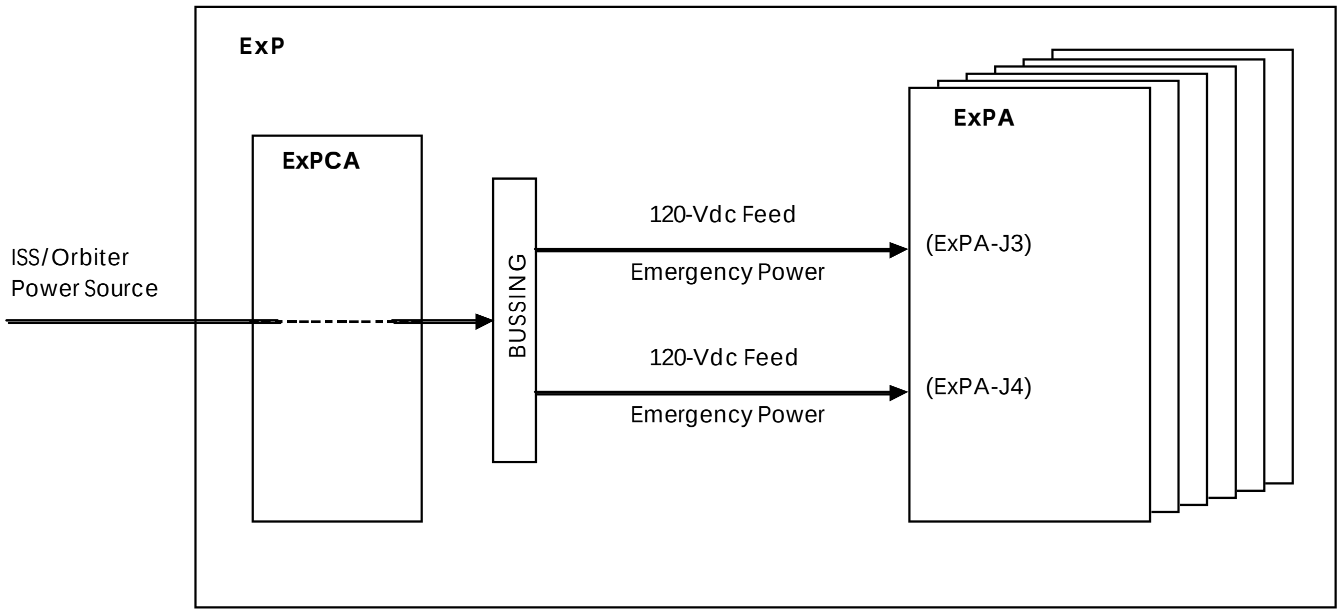
The ExP provides two independently switched/protected 28-Vdc outputs to the ExPA connector panel for on-orbit/stay-alive payload use.



NOTES:

1. Identical power feed complement to each of 6 ExPAs
2. The current capability of each feed is programmable/selectable.

FIGURE 6-1 EXPRESS PALLET POWER DISTRIBUTION SYSTEM OVERVIEW – ON-ORBIT/STAY-ALIVE POWER



NOTES:

1. Identical emergency power feed complement to each of 6 ExPAs
2. Emergency feed switching/control provided by ISS or orbiter power source

FIGURE 6-2 EXPRESS PALLET POWER DISTRIBUTION SYSTEM OVERVIEW – EMERGENCY POWER

6.3.1 28-Vdc Steady-State Voltage Range

The steady-state voltage range of the 28-Vdc feed, for both ISS and orbiter locations, will be 23.0 (TBC) Vdc to 30.2 (TBC) Vdc excluding ripple voltage characteristics. Payload elements utilizing the 28-Vdc service shall be compatible with the output voltage range.

6.3.2 28-Vdc Output Ripple Voltage Characteristic

The 28-Vdc ripple voltage characteristic is defined as follows:

The output ripple voltage will not exceed 0.5 volts (TBC) peak-to-peak. The fundamental switching frequency and its harmonics measured with a 1-MHz (TBC) bandwidth will be less than 1 percent (TBC) of the output voltage. The broadband switching spikes measured with a 50-MHz (TBC) bandwidth will be less than 3 percent (TBC) of the output voltage.

Payload elements utilizing the 28-Vdc service shall be compatible with the ripple voltage characteristic.

6.3.3 28-Vdc Transient Voltage Characteristic

The 28-Vdc output voltage transients will fall within the range of 21.8 (TBC) Vdc to 32.3 (TBC) Vdc including ripple voltage. Voltage transients will return to the nominal output voltage range within 1.0 ms (TBC) after the initial off-nominal excursion. Payload elements requiring the 28-Vdc service shall be compatible with the output voltage transients.

6.3.4 28-Vdc Source Impedance

TBD#6-02

6.3.5 28-Vdc Output Current

6.3.5.1 28-Vdc Output Current Rating

The nominal output current of each 28-Vdc service feed is individually configurable for 5-A, 10-A, 15-A or 20-A current capability.

Payload elements utilizing the 28-Vdc service shall be compatible with the selected output current rating and the planned power-up configuration.

6.3.5.2 28-Vdc Output Overcurrent Protection

The 28-Vdc power outputs will current limit at 125 percent or less of the selected output current from **TBD#6-03** to 50 ms after which time the output ceases to deliver power and switches to the “off” state.

Payload elements utilizing the 28-Vdc service shall be compatible with the overcurrent protection characteristic.

6.3.5.3 28-Vdc Output Surge Current

TBD#6-04

6.3.6 28-Vdc Output Electrical Isolation

6.3.6.1 28-Vdc Output Mutual Isolation

Each 28-Vdc output is isolated from all other 28-Vdc outputs in order to preclude nuisance tripping during the power-up sequence. The payload element shall maintain a mutual isolation between any two 28-Vdc outputs of 1.0 megohm.

6.3.6.2 28-Vdc Output Isolation from Structure

Each 28-Vdc output power and return line shall be isolated from structure by at least 1.0 megohm with a parallel capacitance of $\leq$ 10 μF measured at the payload interface connector while disconnected from the ExP system.

6.4 120-VDC OUTPUT CHARACTERISTICS

The ExP provides four 120-Vdc service feeds to each ExPA for payload use. Two of these feeds are designated for nominal on-orbit/stay-alive payload operations while the remaining two feeds are reserved for payload emergency operation only, and may be used in the event of a loss of nominal operating power due to a failure or malfunction of the ExPCA. Unless otherwise indicated herein, the output voltage characteristics of the 120-Vdc emergency feeds are identical to the characteristics of the nominal on-orbit/stay-alive feeds for the mission phase indicated.

6.4.1 120-Vdc Steady-State Voltage Range

The steady-state voltage ranges of the 120-Vdc feeds are defined in Table 6-I. Payload elements utilizing the 120-Vdc service shall be compatible with the voltage ranges indicated for the carrier location specified.

TABLE 6-I 120-VDC VOLTAGE RANGE (TBC)

MISSION PHASE	LOCATION	VOLTAGE RANGE
Stay-Alive	Orbiter Cargo Bay (post-ascent)	116.0 - 126.0 Vdc
Transition	SRM (Orbiter)	No Power Available
	SSRM (ISS)	No Power Available
	MCAS (ISS MSC Worksite)	107.0 – 126.0 Vdc
On Orbit	S3 Truss Site (ISS)	107.0 – 126.0 Vdc

NOTE: Voltage range excludes ripple voltage.

6.4.2 120-Vdc Ripple Voltage Characteristic

The 120-Vdc output voltage ripple will, under normal conditions, be limited to the levels indicated in Table 6-II. The payload element shall be compatible with the voltage ripple levels indicated.

6.4.3 120-Vdc Transient Voltage Characteristic

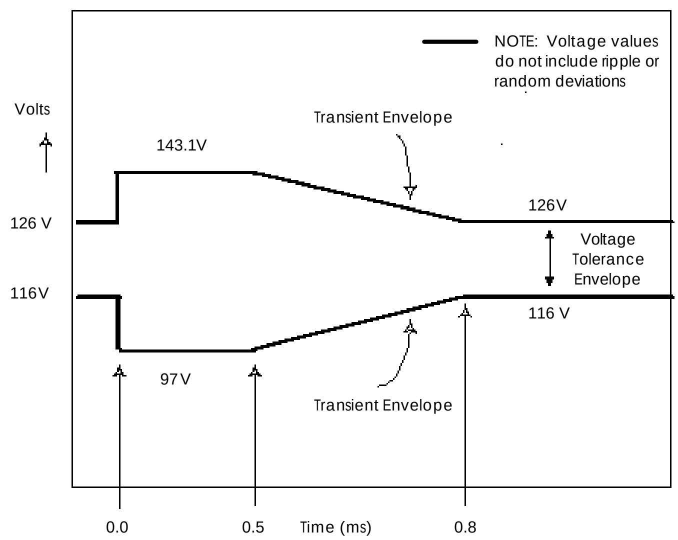
The 120-Vdc output transient voltage characteristic will, under normal conditions, be limited to the magnitude and duration indicated in Figures 6-3 and 6-4. The payload element shall be compatible with the voltage transient characteristic indicated.

6.4.4 120-Vdc Source Impedance

The 120-Vdc source impedance will be as specified in Table 6-III for the indicated mission phases. The payload elements utilizing the 120-Vdc service shall be compatible with the source impedance characteristic.

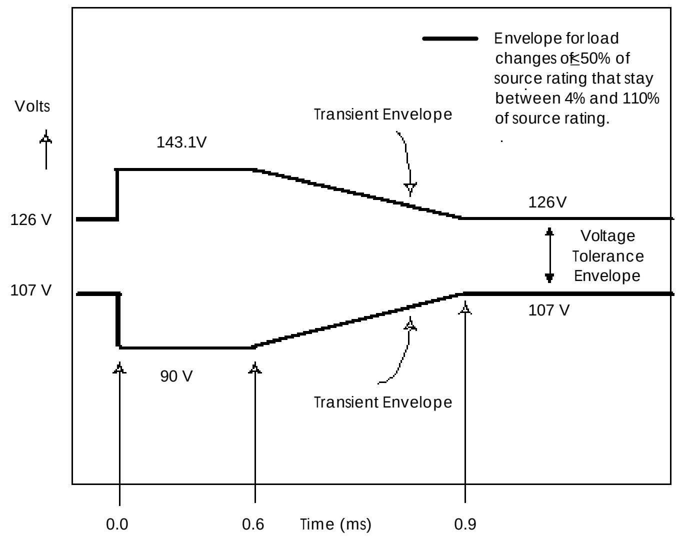
TABLE 6-II 120-VDC FEED RIPPLE VOLTAGE CHARACTERISTIC

MISSION PHASE	LOCATION	RIPPLE VOLTAGE
Stay-Alive	Orbiter Cargo Bay (post-ascent)	The voltage ripple envelope will be no greater than 1.5 volts peak-to-peak for a measurement bandwidth of 20 Hz to 20 MHz.
Transition	SRM (Orbiter)	No power available
	SSRM (ISS)	No power available
	MCAS (ISS MSC Worksite)	The maximum ripple voltage for a fully integrated ExP system will not exceed 2.5 Vrms in a bandwidth from 30 Hz to 1 MHz.
On Orbit	S3 Truss Site (ISS)	



NOTE: The output voltage will remain within this envelope for a positive or negative system step load change from **TBD#6-05** to **TBD#6-06** with a maximum change rate of 200 A/ms.

FIGURE 6-3 120-VDC TRANSIENT VOLTAGE CHARACTERISTIC – STAY-ALIVE (ORBITER) MISSION PHASE (TBC)



NOTES:
- Voltage levels exclude ripple characteristic.
- Transient envelope also applicable to transition phase at MCAS/MSC Worksite.

FIGURE 6-4 120-VDC TRANSIENT VOLTAGE CHARACTERISTIC – ON-ORBIT (ISS) MISSION PHASE (TBC)

TABLE 6-III 120-VDC FEED SOURCE IMPEDANCE CHARACTERISTIC

MISSION PHASE	LOCATION	SOURCE IMPEDANCE
Stay-Alive	Orbiter Cargo Bay (post-ascent)	The source impedance will be within the limits shown in Figure 6-5 under all conditions of source and parallel load conditions that may occur during this mission phase.
Transition	SRM (Orbiter)	No power available
	SSRM (ISS)	No power available
	MCAS (ISS MSC Worksite)	The source impedance will be within the limits shown in Figure 6-6 under all combinations of source and parallel load conditions that may occur during this mission phase.
On Orbit	S3 Truss Site (ISS)	

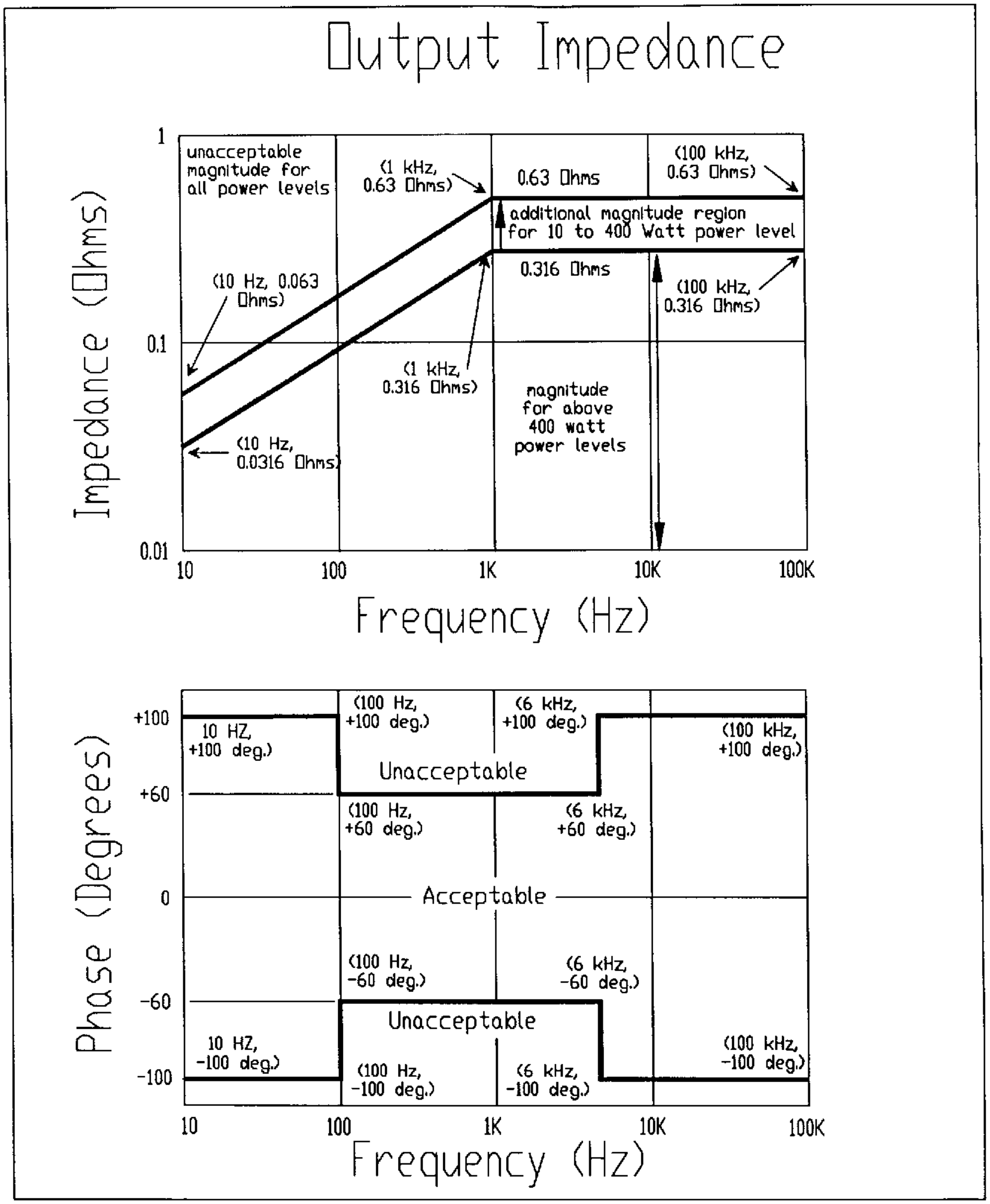
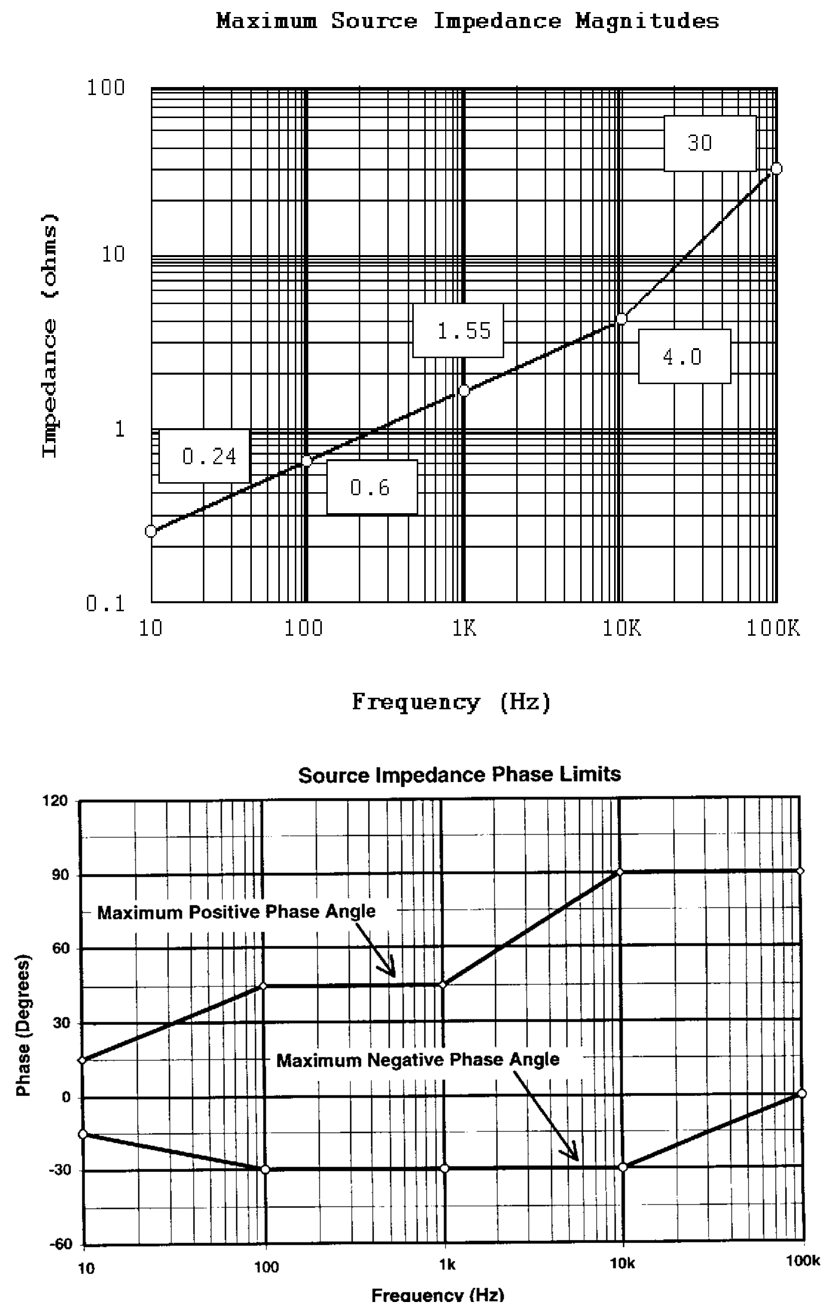


FIGURE 6-5 120-VDC SOURCE IMPEDANCE CHARACTERISTICS – STAY-ALIVE (ORBITER) MISSION PHASE



NOTE: Source impedance characteristics also applicable to transition phase at MCAS/MSC worksite.

FIGURE 6-6 120-VDC SOURCE IMPEDANCE CHARACTERISTICS – ON-ORBIT (ISS) MISSION PHASE

6.4.5 120-Vdc Non-Normal Operation

During the mission on-orbit phase and transition phase at the ISS MSC worksite, the 120-Vdc power quality may exceed the limits for normal operation under equipment failure, fault clearing, or overload conditions. However, excursions from normal power system operations will be within the limits shown in Figure 6-7.

6.4.6 120-Vdc Output Current

6.4.6.1 120-Vdc Output Current Rating (On-Orbit/Stay-Alive Feeds)

The nominal output current of each on-orbit/stay-alive 120-Vdc feed is individually configurable for 2.5-A, 5-A, 7.5-A, or 10-A current capability.

Payload elements utilizing the on-orbit/stay-alive 120-Vdc service shall be compatible with the selected output current rating and the planned power-up configuration.

6.4.6.2 120-Vdc Output Overcurrent Protection

6.4.6.2.1 Overcurrent Protection (120-Vdc On-Orbit/Stay-Alive Feeds)

The individual on-orbit/stay-alive feeds will current limit at 125 percent or less of the selected rated output current from **TBD#6-07** to 50 ms, after which time the output ceases to deliver power and switches to the off state. Payload elements utilizing the 120-Vdc on-orbit/stay-alive power service shall be compatible with the current limiting characteristic of the power output.

6.4.6.2.2 Overcurrent Protection (120-Vdc Emergency Feeds)

6.4.6.2.2.1 120-Vdc Emergency Feed Overcurrent Protection (Orbiter Power Source)

The overcurrent protection characteristic of the emergency feed for an orbiter-located ExP is as follows: The emergency output will current limit at 14.7 to 22 A for a minimum of 100 ms followed by a shutdown between 100 and 300 ms. Payload elements utilizing the 120-Vdc emergency feed shall be compatible with the overcurrent protection feature of the service while located in the orbiter cargo bay.

6.4.6.2.2.2 120-Vdc Emergency Feed Overcurrent Protection (ISS Power Source)

The overcurrent protection characteristic of the emergency feed for an ISS-located ExP is as follows: The emergency output will current limit at 27.5 to 30.0 A. The output

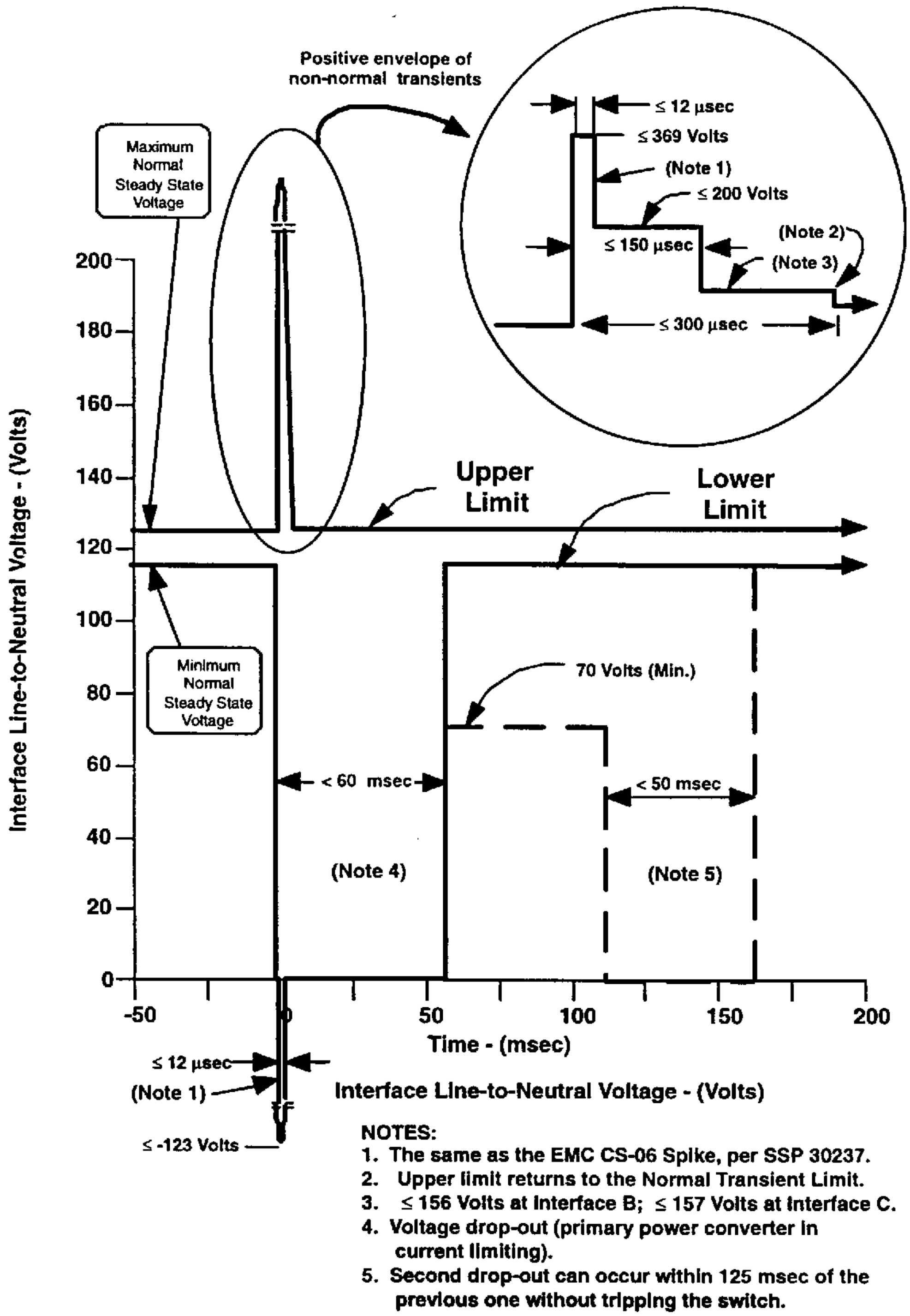


FIGURE 6-7 120-VDC ON-ORBIT (ISS) NON-NORMAL TRANSIENT LIMITS will trip at 28.75 ±1.25 A between 34.5 and 38.0 ms. Payload elements utilizing the 120-Vdc emergency feed shall be compatible with the overcurrent protection feature of the service while located on the ISS.

6.4.6.3 120-Vdc Output Surge Current

6.4.6.3.1 Surge Current (120-Vdc On-Orbit/Stay-Alive Feeds (TBC))

For durations greater than 100 microseconds, the peak surge current drawn by the payload element from the 120-Vdc feed shall (1) be limited to four times the steady-state current for nominal current levels up to 5 A. For nominal current levels greater than 5 A, the surge limit shall (2) be linear from 20 to 23.3 A for steady-state current levels between 5 and 10 A. The maximum allowable current rate of change in A/ms shall (3) be:

$$di/dt = 300 - 5(I)$$

where I = peak surge current.

6.4.6.3.2 Surge Current (120-Vdc Emergency Feeds)

6.4.6.3.2.1 120-Vdc Emergency Feed Surge Current (Orbiter Power Source)

For durations greater than **TBD#6-08** microseconds, the peak surge current drawn by the payload element from the 120-Vdc emergency feed (when derived from the orbiter power source) shall (1) be **TBD#6-09**. The maximum allowable current rate of change permitted shall (2) be 200 A/ms.

6.4.6.3.2.2 120-Vdc Emergency Feed Surge Current (ISS Power Source)

For durations greater than 100 microseconds, the peak surge current drawn by the payload element from the 120-Vdc feed shall (1) be limited to four times the steady-state current for nominal current levels up to 5 A. For nominal current levels greater than 5 A, the surge limit shall (2) be linear from 20 to 33.3 A for steady-state current levels between 5 and 25 A. The maximum allowable current rate of change in A/ms shall (3) be:

$$di/dt = 300 - 5(I)$$

where I = peak surge current.

6.4.6.4 120-Vdc Emergency Feed Soft Start Compatibility (ISS Power Source)

Payload elements utilizing the 120-Vdc emergency power service during the on-orbit (ISS location) mission phase shall be compatible with the soft start/stop characteristics of the feed. The soft start/stop feature is applicable when power is applied, sustained, and removed by control of the ISS Remote Power Control Module (RPCM). The soft start/stop function is active only when the RPCM output is commanded on or off and is limited to 100 A/ms, or less, by the RPCM. The response of the soft start/stop function is linear for resistive loads for 1 to 10 ms. The soft start/stop characteristics of the RPCM are shown in Figure 6-8.

6.4.7 120-Vdc Output Mutual Isolation

Each payload 120-Vdc output is isolated from all other 120-Vdc outputs in order to preclude nuisance tripping during the power-up sequence. The payload element shall maintain a mutual isolation between any two 120-Vdc outputs of 1.0 megohm or greater.

6.5 ALTERNATING CURRENT ISOLATION

Any payload element internal power isolation transformer shall have a primary-to-secondary capacitance of less than 3 percent of the line-to-ground capacitance on the input and output power lines. This may be verified by component level testing of the transformer prior to its integration.

6.6 PAYLOAD POWER ALLOCATION

The ExP will provide up to 2.5 kW of 120-Vdc power to the payload element (1.25 kW per 120-Vdc feed).

The ExP will provide up 1.0 kW of 28-Vdc power to the payload element (500 W per 28-Vdc feed).

During the On-Orbit (ISS) Phase, the maximum 120-Vdc/28-Vdc combined power allocation to the payload element will be 2.5 kW based on ExP constraints. It should be noted that the maximum dc power available to the fully integrated ExP, including its payload complement is 2.5 kW. Therefore, timeline considerations and additional thermal constraints may significantly limit the power available to an individual payload element. Operational timelines for the fully integrated ExP will ultimately dictate the maximum power allocation to any individual payload element.

Table 6-IV defines the maximum power available to the payload element during other mission phases.

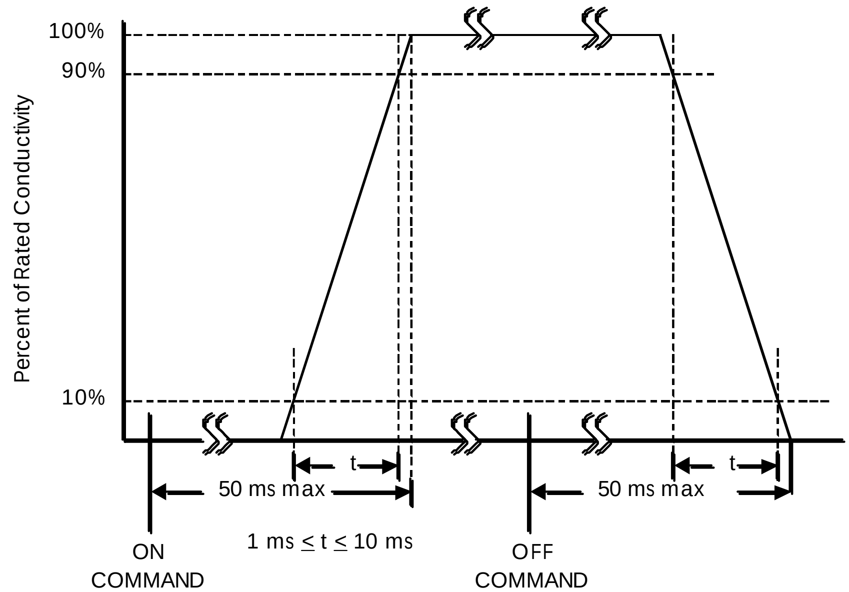


FIGURE 6-8 120-VDC EMERGENCY FEED SOFT START CHARACTERISTIC (ISS POWER SOURCE)

TABLE 6-IV PAYLOAD MAXIMUM POWER AVAILABILITY (TBC)

MISSION PHASE	LOCATION	FEED	POWER ALLOCATION
Stay-Alive	Orbiter Cargo Bay (post-ascent)	28 Vdc 120 Vdc	.12 kW 2.5 kW
Transition	SRM (Orbiter)	N/A	No power available
	SSRM (ISS)	N/A	No power available
	MCAS (ISS MSC Worksite)	28 Vdc 120 Vdc	**TBD#6-10** 2.5 kW
On-Orbit	S3 Truss Site (ISS)	28 Vdc 120 Vdc	1.0 kW 2.5 kW

NOTE: The standard power allocations, as stated in this table, are derived by dividing the maximum power allocation by six for both the 120-Vdc and 28-Vdc feeds. The maximum power delivered to any one ExPA may be 2.5 kW (inclusive of both the 120-Vdc and 28-Vdc feeds). 2.5 kW is also the maximum power available for the entire ExP payload complement. If supplied to a single ExPA, this maximum is subject to at least a power reduction for the stay-alive power requirements of the other payloads. This maximum power will be available for limited durations and is subject to ISS operational timelining of the co-manifested ExP payload power allocations.

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SECTION 7, ELECTROMAGNETIC COMPATIBILITY (EMC)

7.1 CIRCUIT EMC CLASSIFICATIONS

Circuit EMC classifications are defined in Table 7-I. As a design goal, ExP payload wiring on the payload side of the interface should meet the requirements of Table 7-II, or utilize equivalent shielding to minimize Electromagnetic Interference (EMI) affects. In any event, the ExP payload must comply with the radiated and conducted EMC interference requirements of Section 7.3. Bundles of dissimilar classification shall be routed separately so as to provide 20-dB isolation.

7.2 SHUTTLE-PRODUCED INTERFERENCE ENVIRONMENT

7.2.1 Conducted Interference – Shuttle/Cargo Bay

The payload shall be compatible with the requirements stated in Section **TBD#7-01**.

7.2.2 Radiated Interference - Shuttle/Cargo Bay

The shuttle-produced radiated fields environment on which payload design shall be based is limited as follows:

A. Magnetic Fields

(1) The payload shall (1) be compatible with the requirements for power bus-produced magnetic fields in NSTS 21000-IDD-ISS, paragraph 10.7.2.2.1.1.

(2) The payload shall (2) be compatible with the requirements for lightning-produced magnetic fields in NSTS 21000-IDD-ISS, paragraph 10.7.2.2.1.2.

B. Electric Fields

(1) The payload shall (1) be compatible with the requirements for orbiter-installed RF sources electric fields in NSTS 21000-IDD-ISS, paragraph 10.7.2.2.2.1.

(2) The payload shall (2) be compatible with the requirements for EVA RF sources electric fields in NSTS 21000-IDD-ISS, paragraph 10.7.2.2.2.2.

TABLE 7-I CIRCUIT EMC CLASSIFICATIONS

FREQ. OF RISE AND/OR FALL TIME	SOURCE IMPEDANCE (ohms)	LOAD IMPEDANCE (ohms)	VOLTAGE SENSITIVITY	CIRCUIT CLASSIFI-CATION[4]	WIRE TYPE REQD	SHIELD GROUNDING REQMTS
Analog Alternating or Direct Current	<100	<100 - 600 k 0 - 200 0 - 200	>100 mV to <6 V >6 V to ≤40 V >40 V	ML HO EO	TWS TW TW	SPG[2] None None
	≤2.5 k	<100 - 600 k >600 k	<100 mV	ML	TWS TWDS	SPG SPG
	<200	≥200 ≥200 ≥200 V	>100 mV to <6 V >6 V to ≤40 V >40 V	Ml HO EO	TWS TW TW	SPG None None
<50 kHz or Rise and Fall Time >10 µs	<100	<10 k 0 - 200 0 - 200	≤6 V >6 V to ≤40 V >40 V	ML HO EO	TWS TW TW	SPG None None
	≤2.5 k	<100 - 600 k >600 k	<100 mV	ML	TWS TWDS	SPG SPG
	<200	≥200 ≥200 ≥200 V	>100 mV to <6 V >6 V to ≤40 V >40 V	ML HO EO	TWS TW TW	SPG[2] None None
<50 kHz or Rise and Fall Time ≤10 µs ≤1.024 MHz	All	All All	≤100 mV >100 mV to ≤6 V	RF RF	TWDS[1] TWS	MPG MPG
		<1000 ≥1000	>6 V	RF	TWDS[1] TWS	MPG MPG
>1.024 MHz	All	All	All	RF	COAX	MPG

Symbols Used

AF - Audio Frequency	TSP - Twisted Shielded Pair	mV - Millivolts (dc)
Coax - Coaxial	TW - Twisted	µs - microseconds
k - Kilo	TWDS - Twisted Double Shielded	< - less than
kHz - Kilohertz	TWS - Twisted Shielded	≤ - less than or equal to
MHz - Megahertz	V - Volts (dc)	≥ - greater than or equal
MPG - Multiple Point Ground		
RF - Radio Frequency		
SPG - Single Point Ground		

NOTES:

1. If the capacitance per foot is critical, controlled-impedance wiring, special-shielded-twisted pair cables (nominal 75 ohms) should be used.
2. If circuit is balanced by transformer, differential or optical, the shield shall be multi-point grounded to structure.
3. Distance between shield grounds shall not exceed 18 m.
4. The symbols ML, HO, and EO are arbitrary nomenclature to define circuit classification and have no meaning.

TABLE 7-II EXP PAYLOADS EDGE-TO-EDGE BUNDLE SEPARATION REQUIREMENTS[4]

BUNDLE	ROUTED PARALLEL TO BUNDLE	SEPARATION[1, 2] [in inches for parallel runs of D (feet)]			
		1 > D	1 ≤ D < 3	3 ≤ D < 5	D ≥ 5
ML	HO[3]	0	1.0	2.0	4.0
	EO[3]	0	1.5	3.0	6.0
	RF	0	2.5	5.0	10.0
HO[3]	EO[3]	0	0.5	1.0	2.0
	RF	0	1.5	3.0	6.0
EO[3]	RF	0	1.0	2.0	4.0

NOTES:
1. Design goal to keep 3 inches of separation
2. Separation values are in inches.
3. HO and EO referred to switched (on and off) power lines.
4. This table is applicable to both Shuttle and ISS-located hardware items.

7.3 PAYLOAD-PRODUCED INTERFERENCE ENVIRONMENT

7.3.1 Payload-Produced Conducted Noise – Shuttle/Cargo Bay

The payload-produced conducted emission limits shall meet the following requirements.

A. 28-Vdc Power

(1) The payload shall be compatible with the requirements of NSTS 21000-IDD-ISS, paragraph 10.7.3.1.1.

B. 120-Vdc Power

(1) The payload shall be compatible with the requirements of NSTS 21000-IDD-ISS, paragraph 10.7.3.1.2.

7.3.2 Payload-Produced Radiated Fields – Shuttle/Cargo Bay

The payload-produced radiated fields environment on which payload design shall be based is limited as follows:

A. Magnetic Fields

(1) The payload shall be compatible with the requirements for dc magnetic fields in NSTS 21000-IDD-ISS, paragraph 10.7.3.2.1.

B. Electric Fields

(1) The payload shall (1) be compatible with the requirements for unintentional radiated electric fields in NSTS 21000-IDD-ISS, paragraph 10.7.3.2.2.1.

(2) The payload shall (2) be compatible with the requirements for intentional radiated electric fields in NSTS 21000-IDD-ISS, paragraph 10.7.3.2.2.2.

(3) The payload shall (3) be compatible with the requirements for Electrostatic Discharge (ESD) electric fields in NSTS 21000-IDD-ISS, paragraph 10.7.3.2.2.3.

7.4 ELECTROMAGNETIC COMPATIBILITY

EMC requirements for ISS compatibility are as follows.

7.4.1 Emission and Susceptibility Limits and Test Methods

These requirements apply to payload electronic, electrical, electromechanical equipment, and subsystems emissions and susceptibilities. Approval of design procedures and techniques does not relieve the PD of the responsibility of meeting the emission and susceptibility test limits. The threshold of susceptibility shall (1) be determined for equipment unable to meet the susceptibility test limits.

Testing of the equipment to ensure compliance to the requirements of this document shall (2) be performed using the test methods given in Space Station Electromagnetic Emission and Susceptibility Requirements, SSP 30237, as amended in SSP 52000-PVP-EPP.

7.4.1.1 Self-Compatibility

The payload, designed in accordance with the EMC requirements, shall not malfunction, and performance shall not be degraded during EMI testing.

7.4.1.2 Conducted Emissions

7.4.1.2.1 CE01, Conducted Emissions

CE01 applies to dc input power leads, 30 Hz to 15 kHz.

CE01 is applicable only for narrowband emissions between 30 Hz and 15 kHz on dc leads which obtain power from other sources or provide power to other equipment, distribution panels, or subsystems.

7.4.1.2.2 CE01 Limits

Payload narrowband conducted emissions in excess of the values shown below shall (1) not appear on dc input power leads. The emissions limit shown in Table 7-III is for equipment drawing 1 A or less. For equipment drawing more than 1 A, the limit, in decibels shown below shall (2) be raised by 20 log I, where I equals the total dc current used by the Equipment Under Test (EUT).

TABLE 7-III CE01 LIMITS

FREQUENCY	EMISSIONS
30 Hz - 200 Hz	110 dB above 1 μA
200 Hz - 15 kHz	Decreasing log-linearly with increasing frequency from 110 dB to 74 dB above 1 μA

The emissions limits shall (3) be measured with an effective bandwidth not exceeding 100 Hz.

7.4.1.2.3 CE03, Conducted Emissions

CE03 applies to dc input power leads, 15 kHz to 50 MHz.

CE03 is applicable only for narrowband emissions between 15 kHz and 50 MHz on dc leads which obtain power from other sources or provide power to other equipment, distribution panels, or subsystems.

7.4.1.2.4 CE03 Limits

Payload narrowband conducted emissions in excess of the values shown in Table 7-IV shall (1) not appear on dc input power leads. The limit shown in Table 7-IV is for equipment drawing 1 A or less. For equipment drawing more than 1 A, the limit shown in Table 7-IV shall (2) be raised 20 x log I, where I equals the total dc current used by the EUT.

7.4.1.2.5 CE07, Conducted Emissions

CE07 applies to dc input power leads, spikes, and time domain transients. CE07 is applicable for all 120-Vdc and 28-Vdc input power leads.

TABLE 7-IV CE03 LIMITS

FREQUENCY	EMISSIONS
15 kHz - 500 kHz	Decreasing log-linearly with increasing frequency from 74 dB to 45 dB above 1 μA
500 kHz - 50 MHz	45 dB above 1 μA

7.4.1.2.6 CE07 Limits

Payload CE07 on/off and operating mode switching transients shall (1) not exceed the envelope defined by the values listed in Table 7-V. Repetitive on/off and mode switching transients shall (2) not occur more frequently than every 100 ms.

TABLE 7-V CE07 LIMITS

TIME (μA)	PERCENTAGE OF NOMINAL LINE VOLTAGE
0.1 - 10	±50 percent
10 - 50	Decreasing log-linearly with increasing time from ±50 percent to ±20 percent
50 - 1,000	Decreasing log-linearly with increasing time from ±20 percent to ±5 percent
1,000 - 10,000	+6 percent or +0.5 V, whichever is greater
10,000 - 100,000	+5 percent or +0.5 V, whichever is greater

7.4.1.3 Conducted Susceptibility

7.4.1.3.1 CS01, Conducted Susceptibility

CS01 applies to dc input power leads in the frequency range of 30 Hz to 50 kHz. CS01 is applicable to payload equipment using 120-Vdc and 28-Vdc input power.

7.4.1.3.2 CS01 Limits

The payload shall not exhibit any malfunction, degradation of performance, or deviation from specified indications beyond the tolerances indicated in the individual payload equipment specification when subjected to electromagnetic energy injected onto its power leads less than or equal to the values as shown in Table 7-VI. The requirement is also considered met when the audio power source specified in the test method below, adjusted to dissipate 50 W in a 0.5-ohm load, cannot develop the required voltage at the EUT power input terminals, and the EUT is not susceptible to the output of the signal source.

TABLE 7-VI CS01 LIMITS

FREQUENCY	VOLTAGE
30 Hz - 2 kHz	0.7 Vrms
2 kHz - 50 kHz	Decreasing log-linearly from 0.7 Vrms at 2 kHz to 0.28 Vrms at 50 kHz

7.4.1.3.3 CS02, Conducted Susceptibility

CS02 applies to dc power leads in the frequency range of 50 kHz to 50 MHz. CS02 is applicable to payload equipment using 120-Vdc and 28-Vdc input power.

7.4.1.3.4 CS02 Limits

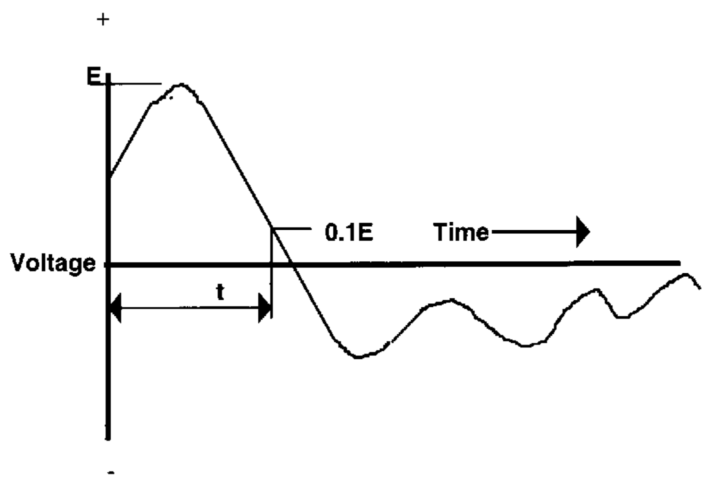
The payload shall (1) not exhibit any malfunction, degradation of performance, or deviation from specified indications beyond the tolerances indicated in the individual payload equipment specification when subjected to 0.28 Vrms from a 50-ohm source. The test signal shall (2) be applied to the equipment power line near the equipment input terminals. The requirement is also considered met under the following condition: when a 1-W source of 50-ohm impedance cannot develop the required voltage at the EUT power input terminals, and the EUT is not susceptible to the output of the signal source.

7.4.1.3.5 CS06, Conducted Susceptibility

CS06 defines transients to be applied to 120-Vdc and 28-Vdc power leads for test purposes. CS06 is applicable to all payload equipment using 120-Vdc and 28-Vdc power.

7.4.1.3.6 CS06, Limits

The payload shall (1) not exhibit any malfunction, degradation of performance, or deviation from specified indications beyond the tolerances indicated in the individual payload equipment specification when the test spikes, each having the waveform shown on Figure 7-1, are applied sequentially to the dc power input leads. The values of E and t are given below. Each spike shall (2) be superimposed on the power line voltage waveform.



The EUT shall be subjected to the spike(s) with the waveform shown and with the specified voltage(s) and pulsewidth (s)

Spike #1E = ±Twice times the nominal line voltage, t = 10 microseconds ±20 percent.
Spike #1E = ±Twice times the nominal line voltage, t = 0.15 microseconds ±20 percent.

FIGURE 7-1 CS06 AND RS02 PAYLOAD EQUIPMENT LIMIT

7.4.1.4 Radiated Emissions

7.4.1.4.1 RE02, Radiated Emissions

Electric field, 14 kHz to 10 GHz (narrowband), 13.5 to 15.5 GHz.

RE02 is applicable for radiated emissions from equipment and subsystems, cables (including control, pulse, IF, power and antenna transmission lines) and interconnecting wiring of the EUT; for narrowband emissions, it applies at the fundamental frequencies and all spurious emissions including harmonics, but does not apply for radiation from antennas. This requirement is applicable for narrowband emissions from 14 kHz to 10 GHz, 13.5 to 15.5 GHz.

7.4.1.4.2 RE02 Limits

Payload E-field emissions shall not be radiated in excess of those specified in the following paragraphs. Above 30 MHz, the limits are to be met for both horizontally and vertically polarized waves. Measurement is to be made in the peak detector mode.

7.4.1.4.3 Narrowband Electric Field Emissions

Payload narrowband E-field emissions shall not be radiated in excess of the following values as shown in Table 7-VII and in Figure 7-2 at the required test distance, 1 m.

TABLE 7-VII RE02 LIMITS

FREQUENCY	EMISSIONS
14 kHz - 10 MHz	56 dB μV per meter
10 MHz - 259 MHz	Increasing log-linearly with increasing frequency from 56 to 86 dB μV per meter (16 dB per decade)
259 MHz - 10 GHz	Increasing log-linearly with increasing frequency from 46 to 72 dB μV per meter (16 dB per decade)
13.5 MHz - 15.5 GHz	76 dB μV per meter

7.4.1.5 Radiated Susceptibility

7.4.1.5.1 RS02, Radiated Susceptibility

Magnetic induction field.

RS02 is applicable for all equipment and subsystems. These susceptibility signals are electromagnetically coupled into the equipment and/or subsystem wiring.

7.4.1.5.2 RS02 Limits

The payload shall not exhibit any malfunction, degradation of performance, or deviation from specified indications beyond the tolerances indicated in the individual equipment or subsystem specification when subjected sequentially to the test spikes, shown in Figure 7-1, each having the waveform with the values of E and t as given below:

7.4.1.5.3 RS03, Radiated Susceptibility

Electric field, 14 kHz to 20 GHz.

RS03 is applicable for all equipment and subsystems between 14 kHz and 20 GHz. Above 10 GHz, this requirement applies only at specific frequencies and magnitudes known to be present at the ISS. Below 10 GHz, this requirement shall be increased only at specific frequencies and amplitudes known to be present at the ISS. Module shielding effectiveness can be used to limit the levels applied.

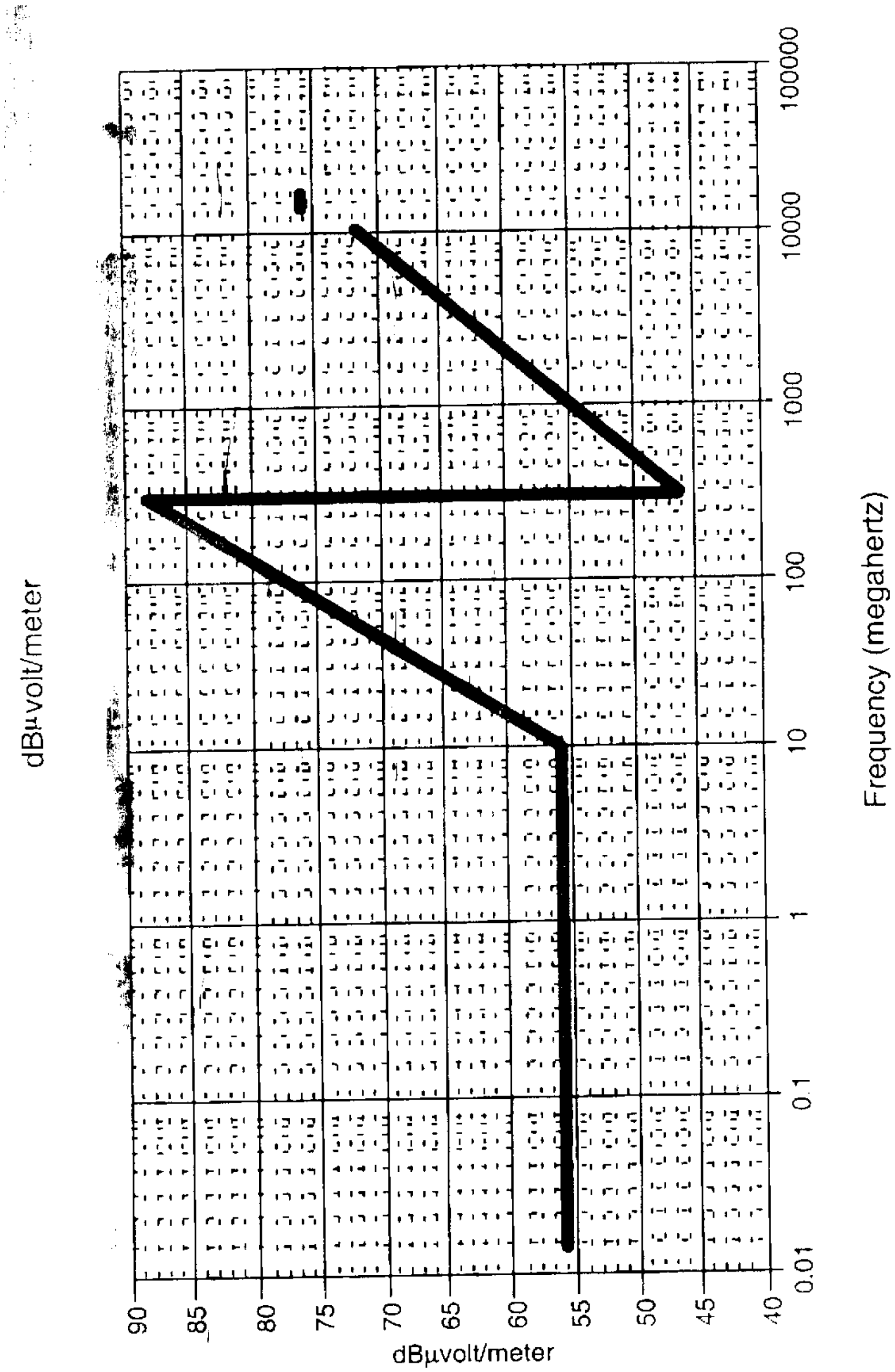


FIGURE 7-2 NARROWBAND E-FIELD EMISSIONS LIMITS

7.4.1.5.4 RS03 Limits

The payload shall not exhibit any malfunction, degradation of performance, or deviation, from specified indications beyond the tolerances indicated in the individual equipment or subsystem specification when subjected to the radiated electric fields less than or equal to those specified herein. Above 30 MHz, the requirement is to be met for both horizontally and vertically polarized waves. As a minimum, the levels in Table 7-VIII apply at either the specific frequencies stated or across the ranges stated.

TABLE 7-VIII RS03 LIMITS

FREQUENCY/RANGE	RADIATED ELECTRIC FIELD LEVEL
14 kHz - 10 MHz	5 V/m
200 MHz - 8 GHz	60 V/m
8 GHz - 10 GHz	20 V/m
2.2 GHz	161 V/m
8.5 GHz	79 V/m
13.7 GHz - 15.2 GHz	250 V/m

7.4.2 Electrostatic Discharge

7.4.2.1 ESD Compatibility

Unpowered PD electrical equipment and components shall fail safe or shall not be damaged by ESD equal to or less than 4,000 V to the case or any pin on external connectors. These voltages are the result of charges accumulated and discharged from ground personnel or crewmembers during equipment installation or removal.

7.4.2.2 ESD Labeling

PD electrical equipment that may be damaged by ESD between 4,000 and 15,000 V shall have a label affixed to the case in a location clearly visible in the installed position and is to be in accordance with MIL-STD-1686.

7.4.2.3 Corona

Electrical and electronic subsystems, equipment, and systems shall be designed to preclude damaging or destructive corona in its operating environment. An analysis must be performed to verify the corona does not create damaging or destructive effects in accordance with SSP 30243.

Design Guidance for meeting the corona requirement is found in MSFC-STD-531, High Voltage Design Criteria.

7.5 ELECTRICAL BONDING

The payload-to-ExP electrical bonding interface shall (1) be electrically bonded to provide homogeneous electrical characteristics. All electrical and mechanical elements shall (2) be securely bonded to structure in accordance with SSP 30245. Three classes of bonds are applicable to either cargo bay, ExP, or both: Classes C, R, and S. These bond classes are defined in the following paragraphs. These definitions will be used in further discussion on bonding requirements.

A. Fault Current Bond - Class C

All payload elements using ExP facility power shall have mechanically secure electrical connections to the ExP structure capable of carrying the maximum return fault current.

B. RF Bond - Class R

Payload elements containing electrical circuits which generate radio frequencies or circuits which are susceptible to RF interference may require a low impedance path to structure in order to comply with EMC requirements. The dc resistance of the Class R bond between the ExP interface and structure shall be less than 2.5 milliohms for each joint. (Class C bond requirements shall also apply if electrical power is utilized).

C. Static Bond - Class S

The resistance of this interface bond to structure shall be less than 1 ohm.

7.5.1 Electrical Bonding of Payload Hardware

All payload electrical equipment shall (1) always meet the Class C bonding requirements. Payload equipment which generates and/or is susceptible to RF interference shall (2) have a Class R bond.

In addition, the metallic shells of all electrical connectors shall (3) be electrically bonded to the payload equipment case or the payload equipment bulkhead mount with a class R bond.

Wire harness shields external to equipment, requiring grounding at the payload equipment, shall (4) have provisions for grounding the shields to the payload equipment through the harness connector backshell.

7.5.2 Electrical Bonding of Payload Structures

7.5.2.1 Payload-to-ExPA Main Bond

There are accommodations available on the ExPA to provide bonding surfaces/paths for the payload user. These are detailed below.

A. Payload-to-ExPA Bond Strap

If this method is chosen, the payload-to-ExPA bond strap is to be payload provided and shall (1) be designed to be connected between ExPA structure and the payload's ground attachment provisions. This bond shall (2) meet the requirements of Section 7.5, Electrical Bonding, and shall (3) have less than or equal to 2.5 milliohms (Class R) at each junction of the fault current interface.

B. Payload-to-ExPA Mated Surface Bond

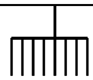
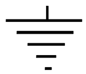
All aluminum surfaces used for bonding the payload shall (1) be originally cleaned to bare metal, then chemically filmed per MIL-C-5541, Class 3 (gold alodine 1200LN9368 or equivalent). The maximum resistance between the mated surfaces of the bond connection (connector to mounting base, mounting base to ExPA, or when applicable, mounting base to payload) shall (2) be less than or equal to 2.5 milliohms (Class R) at each junction of the fault current interface. There are only certain places with prepared surfaces on the ExPA backplate, so to properly utilize this option the ExP integrator must be contacted.

7.5.2.2 Electrical Bonding for Static Protection

All payload hardware elements also shall be designed to preclude the accumulation of an electrostatic charge on their surfaces.

7.5.3 Circuit Reference Symbols

The circuit reference symbols for use on the ExP payload will be as illustrated and defined as follows:

	Structure reference - a connection to ExP structure.
	Primary power reference - a connection to the ExP primary dc power return.

7.6 POWER CIRCUIT ISOLATION AND GROUNDING

7.6.1 ExP 120-Vdc and 28-Vdc Primary Power Bus Isolation

Payload input power and return lines shall (1) be isolated from structure by at least 1.0 megohm with a parallel capacitance of ≤10 μF measured at the payload interface connector contacts. Isolation and grounding requirements for the payload power and signal interfaces shall (2) be per Figure 7-3.

7.6.2 Dc Power Ground Reference

ExP dc power supplied to a payload is structure referenced in the ExP and dc isolated from structure ground at the payload by greater than 1 megohm with a parallel capacitance of ≤10 μF. The ExP primary dc power return system is a combination of a hardwired return system and a structure-return system, with the use of the wire return restricted to specific load-sensitive areas.

7.6.3 Payload Secondary Power Isolation and Grounding

ExP 120-Vdc and 28-Vdc primary power bus and payload secondary power shall (1) be isolated by a minimum of 1 megohm. Secondary power return lines shall (2) be single point grounded to structure.

7.6.4 GSE Isolation and Grounding

GSE interfacing with payloads shall (1) have power returns isolated from payload structures by a minimum of 1 megohm, except where balanced (i.e., differential) circuits are used. In the case of balanced (i.e., differential) circuits, each side of the circuit shall (2) be balanced to ground by no less than 4 kilohm. COAX cables, with their inherent grounding of the signal return to structure, are permitted, provided their interface with other payload or systems does not propagate that ground to circuits that are already referenced to ground at some other point.

TBD#7-02

FIGURE 7-3 PAYLOAD ISOLATION AND GROUNDING FOR EXP

7.7 SIGNAL ISOLATION AND GROUNDING REQUIREMENTS

The payload isolation and grounding requirements for received and transmitted signals are as follows:

7.7.1 Ethernet

Isolation and grounding for received and transmitted signals shall be per IEEE 802.3.

7.7.2 Analog

Transmitting signal lines shall be referenced to signal ground at the source. Signal lines will be isolated from ExPCA ground by 1 megohm or greater.

See Section 9.3.2, Analog Driver Characteristics.

7.7.3 Discrete

Received signal and return lines shall (1) be isolated from chassis ground by a minimum of 10 kilohm shunted by equal to or less than 1 nF. Transmitting signal lines shall (2) be referenced to signal ground at the source.

See Section 9.4.2, Discrete Driver and Receiver Characteristics.

7.7.4 Shield References

The design criteria for wire shield references shall be per the data given in Table 7-I.

SECTION 8, ELECTRICAL POWER AND DATA WIRING INTERFACE

8.1 GENERAL

Power and data interface provisions will be available through ExPA connector panels at the locations shown in Figures 3-15 and 3-16.

8.2 CONNECTOR TYPES

It is the intent that all electrical interface connectors be supplied by the ExP facility. If an ExP payload element chooses to supply electrical connectors and connector contacts that interface with the ExP, they shall be compatible NASA Threaded Coupling (NATC) connectors per SSQ 21635 and shall be intermateable with the connector receptacles indicated in Table 8-I.

8.3 CABLE DESIGN AND CONSTRUCTION

Design Guidance: It is recommended that payload-provided cables which interface directly with the ExP be designed and fabricated in accordance with NASA-STD-8739.4.

8.4 CABLE INSTALLATION AND ROUTING

The PD is responsible for routing and specifying the attachment hardware and methodology to support the interfacing cables. Cable clamps and supports shall (1) be placed at intervals of 18 in (457 mm), or less, such that the cable vibration and shock will be minimized. Cables shall (2) be routed so that they are protected from abrasion, cold flow, and cut through. Cable routing shall (3) not impede removal or installation of other payload hardware items.

8.5 WIRING DETAILS AND PIN ASSIGNMENTS (TBC)

Power and data cable wiring details and pin assignments are shown in Table 8-I. The interfacing payload cables shall be compatible with the details and pin assignments in Table 8-I.

TABLE 8-I ExPA CONNECTOR INTERFACE DEFINITION (TBC) (Sheet 1 of 4)

ExPA CONN DES (NOMENCLATURE)	ExPA CONNECTOR TYPE (RECOMMENDED PL MATING CONN)	CONTACT POSITION	CONNECTOR CONTACT SIZE	SIGNAL DEFINITION	RECOMMENDED WIRE TYPE	REMARKS
ExPA-J1 (120 Vdc Power) [Panel 1]	NATC007T15N5SN (NATC06G15N5PN)	TBD#8-01	16	120 Vdc Power	M27500-16RE2U00 per MIL-C-27500	NOTE: AWG 16 wire size is TBC and subject to change.
		TBD#8-01		120 Vdc Return		
		TBD#8-01		SPARE		
		TBD#8-01		SPARE		
		TBD#8-01	16	SPARE		
ExPA-J2 (120 Vdc Power) [Panel 1]	NATC00T15N5SA (NATC06G15N6PA)	TBD#8-01	16	120 Vdc Power	M27500-12RE2U00 per MIL-C-27500	NOTE: AWG 16 wire size is TBC and subject to change.
		TBD#8-01		120 Vdc Return		
		TBD#8-01		SPARE		
		TBD#8-01		SPARE		
		TBD#8-01	16	SPARE		
ExPA-J3 (120 Vdc Emergency Power) [Panel 1]	NATC00T15N4SN (NATC06G15N4PN)	TBD#8-01	12	120 Vdc Power	M27500-12RE2U00 per MIL-C-27500	
		TBD#8-01		120 Vdc Return		
		TBD#8-01		SPARE		
		TBD#8-01	12	SPARE		
ExPA-J4 (120 Vdc Emergency Power)	NATC00T15N4SA (NATC06G15N4PA)	TBD#8-01	12	120 Vdc Power	M27500-12RE2U00 per MIL-C-27500	
		TBD#8-01		120 Vdc Return		
		TBD#8-01		SPARE		
		TBD#8-01	12	SPARE		
ExPA-J5 (28 Vdc Power)	NATC07T17N6SN (NATC06G17N6PN)	TBD#8-01	12	28 Vdc Power	M27500-12RE2U00 per MIL-C-27500	12 AWG wire is recommended. Smaller wire sizes must utilize special crimping techniques.
		TBD#8-01		28 Vdc Return		
		TBD#8-01		SPARE		
		TBD#8-01		SPARE		
		TBD#8-01		SPARE		
		TBD#8-01	12	SPARE		

NOTE: ExPA connector designator and connector types are highly subject to change pending ExPS PDR data.

TABLE 8-I ExPA CONNECTOR INTERFACE DEFINITION (TBC) (Sheet 2 of 4)

ExPA CONN DES (NOMENCLATURE)	ExPA CONNECTOR TYPE (RECOMMENDED PL MATING CONN)	CONTACT POSITION	CONNECTOR CONTACT SIZE	SIGNAL DEFINITION	RECOMMENDED WIRE TYPE	REMARKS
ExPA-J6 (28 Vdc Power) [Panel 1]	NATC07T17N6SA (NATC06G17N6PA)	TBD#8-01	12	120 Vdc Power	M27500-12RE2U00 per MIL-C-27500	12 AWG wire is recommended. Smaller wire sizes must utilize special crimping techniques.
		TBD#8-01		120 Vdc Return		
		TBD#8-01		SPARE		
		TBD#8-01		SPARE		
		TBD#8-01		SPARE		
		TBD#8-01	12	SPARE		
ExPA-J6 (ANALOG INSTM) [Panel 2]	NATC07T11N35PN (NATC06G11N35SN)	TBD#8-01	22D	ANLG CH1 (+)	M27500-22RE2N06 per MIL-C-27500	
		TBD#8-01		ANLG CH1 (-)		
		TBD#8-01		ANLG CH1 SHLD		
		TBD#8-01		ANLG CH2 (+)		
		TBD#8-01		ANLG CH2 (-)		
		TBD#8-01		ANLG CH2 SHLD		
		TBD#8-01		ANLG CH3 (+)		
		TBD#8-01		ANLG CH3 (-)		
		TBD#8-01		ANGL CH3 SHLD		
		TBD#8-01		SPARE		
		TBD#8-01		SPARE		
		TBD#8-01		SPARE		
		TBD#8-01	22D	SPARE		

NOTE: ExPA connector designator and connector types are highly subject to change pending ExPS PDR data.

TABLE 8-I ExPA CONNECTOR INTERFACE DEFINITION (TBC) (Sheet 3 of 4)

ExPA CONN DES (NOMENCLATURE)	ExPA CONNECTOR TYPE (RECOMMENDED PL MATING CONN)	CONTACT POSITION	CONNECTOR CONTACT SIZE	SIGNAL DEFINITION	RECOMMENDED WIRE TYPE	REMARKS
ExPA-J8 (ANALOG INSTM) [Panel 2]	NATC07T11N35PA (NATC06G11N35SA)	TBD#8-01	22D	ANLG CH4 (+)	M27500-22RE2N06 per MIL-C-27500	
		TBD#8-01		ANLG CH4 (-)		
		TBD#8-01		ANLG CH4 SHLD		
		TBD#8-01		ANLG CH5 (+)		
		TBD#8-01		ANLG CH5 (-)		
		TBD#8-01		ANLG CH5 SHLD		
		TBD#8-01		ANLG CH6 (+)		
		TBD#8-01		ANLG CH6 (-)		
		TBD#8-01		ANGL CH6 SHLD		
		TBD#8-01		SPARE		
		TBD#8-01		SPARE		
		TBD#8-01		SPARE		
		TBD#8-01	22D	SPARE		
ExPA-J9 (Discrete INSTM) [Panel 2]	NATC07T9N35PN (NATC06G9N35SN)	TBD#8-01	22D	DISC I/O CH1 (+)	M27500-22RE2U00 per MIL-C-27500	
		TBD#8-01		DISC I/O CH1 (-)		
		TBD#8-01		DISC I/O CH2 (+)		
		TBD#8-01		DISC I/O CH2 (-)		
		TBD#8-01		DISC I/O CH3 (+)		
		TBD#8-01	22D	DISC I/O CH3 (-)		
ExPA-J10 (Discrete INSTM) [Panel 2]	NATC07T9N35PA (NATC06G9N35SA)	TBD#8-01	22D	DISC I/O CH4 (+)	M27500-22RE2U00 per MIL-C-27500	
		TBD#8-01		DISC I/O CH4 (-)		
		TBD#8-01		DISC I/O CH5 (+)		
		TBD#8-01		DISC I/O CH5 (-)		
		TBD#8-01		DISC I/O CH6 (+)		
		TBD#8-01	22D	DISC I/O CH6 (-)		

NOTE: ExPA connector designator and connector types are highly subject to change pending ExPS PDR data.

TABLE 8-I ExPA CONNECTOR INTERFACE DEFINITION (TBC) (Sheet 4 of 4)

ExPA CONN DES (NOMENCLATURE)	ExPA CONNECTOR TYPE (RECOMMENDED PL MATING CONN)	CONTACT POSITION	CONNECTOR CONTACT SIZE	SIGNAL DEFINITION	RECOMMENDED WIRE TYPE	REMARKS
ExPA-J11 (1553/Ethernet) [Panel 2]	NATC07T11N35PB (NATC06G11N35SB)	TBD#8-01	22D	1553/RT1-A (+)	SSQ 21655	Maximum cable length shall be 10 ft.
		TBD#8-01		1553/RTI-A (-)		
		TBD#8-01		1553/RT1-A (SHLD)		
		TBD#8-01		1553/RT1-B (+)		
		TBD#8-01		1553/RT1-B (-)		
		TBD#8-01		1553/RT1-B (SHLD)		
		TBD#8-01		TD (+)	100Base-TX	Wire type exception: Type shall be stranded – twisted pair/shielded. Wire pair characteristic impedance: 100 +/-15 ohms, category 5 rated wire
		TBD#8-01		TD (-)		
		TBD#8-01		TD (SHLD)		
		TBD#8-01		RD (+)		
		TBD#8-01		RD (-)		
		TBD#8-01		RD (SHLD)		
		TBD#8-01	22D	SPARE		
ExPA-J12 (1553/Ethernet) [Panel 2]	NATC07T11N35PC (NATC06G11N35SC)	TBD#8-01	22D	1553/RT2-A (+)	SSQ 21655	Maximum cable length shall be 10 ft.
		TBD#8-01		1553/RT2-A (-)		
		TBD#8-01		1553/RT2-A (SHLD)		
		TBD#8-01		1553/RT2-B (+)		
		TBD#8-01		1553/RT2-B (-)		
		TBD#8-01		1553/RT2-B (SHLD)		
		TBD#8-01		TD (+)	100Base-TX	Wire type exception: Type shall be stranded – twisted pair/shielded. Wire pair characteristic impedance: 100 +/-15 ohms, category 5 rated wire
		TBD#8-01		TD (-)		
		TBD#8-01		TD (SHLD)		
		TBD#8-01		RD (+)		
		TBD#8-01		RD (-)		
		TBD#8-01		RD (SHLD)		
		TBD#8-01	22D	SPARE		

NOTE: ExPA connector designator and connector types are highly subject to change pending ExPS PDR data.

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SECTION 9, COMMAND AND DATA HANDLING (C&DH) INTERFACES

There are various C&DH interfaces available for ExP payloads. Figure 9-1 illustrates the payload-to-ExP C&DH interfaces. Each of these interfaces is defined in the following paragraphs. There are no audio or video interfaces available on the ExP.

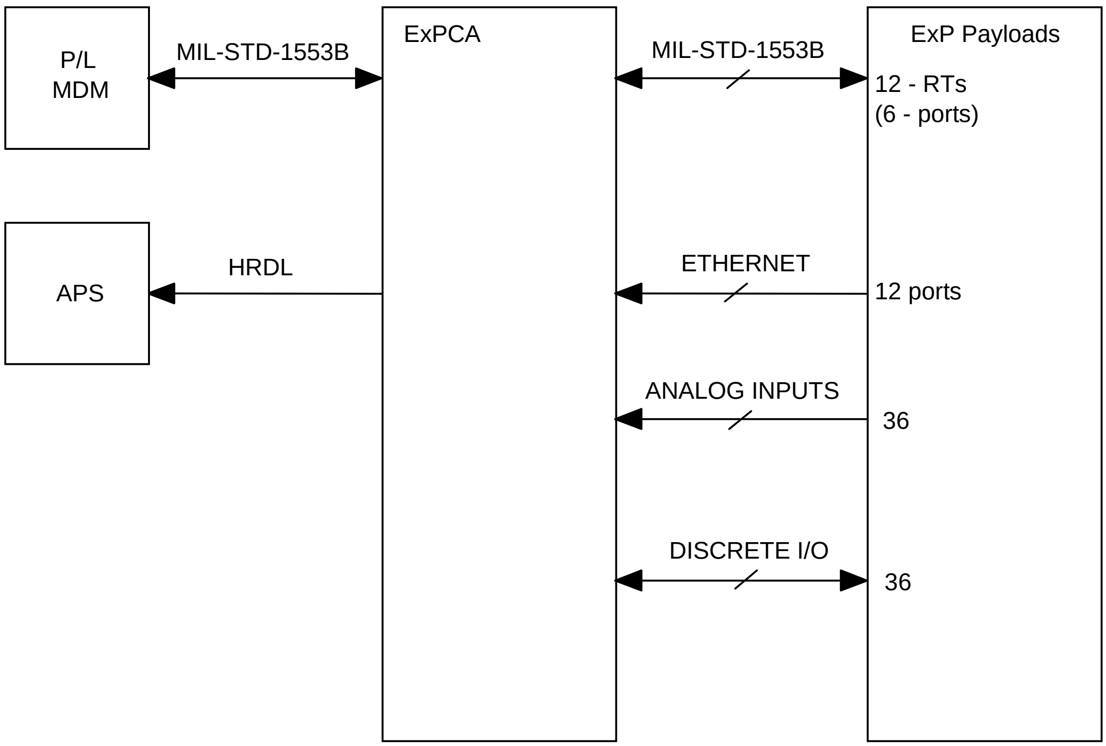

FIGURE 9-1 EXP PAYLOAD C&DH INTERFACES

9.1 MIL-STD-1553B COMMUNICATIONS

9.1.1 Signal Characteristics

Payloads using the MIL-STD-1553B bus shall (1) meet the interface and signal characteristics requirements of the MIL-STD-1553.

Payloads shall (2) meet the terminal characteristics in accordance with paragraph 4.5.2, “Terminal Characteristics” of MIL-STD-1553B.

9.1.2 Processing Requirements

All payload Health and Status data will be obtained at a 1-Hz rate. The payload shall be capable of providing two 32-word packets per second.

Note: Health and Status packet allocation to an ExP payload may be available in one to four 32-word packets subject to the Health and Status requirements of the co-resident ExP payloads and to ExPCA application software design limitations.

9.2 ETHERNET COMMUNICATIONS

9.2.1 Signal Characteristics

Payloads interfacing with the ExPCA shall meet the requirements and signal characteristics of ISO/IEC 8802-3 (10BASE-T section).

9.2.2 Communications Protocol

Payloads communicating with the ExPCA via Ethernet shall use software protocol Transmission Control Protocol/Internet Protocol (TCP/IP).

9.2.3 Throughput Requirements

ExP payloads shall not exceed a maximum sustained data rate of 6 Mbps.

9.3 ANALOG COMMUNICATIONS

Analog interfaces provide for temperature, pressure, and preconditioned signal (analog voltage) inputs. These inputs are configurable to be operated in either a current or voltage mode.

It should be noted that all analog communications are via the ExPCA. The sampling rate of the payload data by the ExPCA will be 1 Hz. All analogs for a single payload location must be sampled at the same rate. The resolution/accuracy of the payload data by the ExPCA will be 12 bits including sign. (TBC)

9.3.1 Temperature Monitoring Signal Characteristics

An analog signal input to the ExPCA shall (1) be a $\pm$5 Vdc (TBC) output signal. The dc input impedance shall (2) be greater than or equal to 1 megohm.

9.3.2 Pressure Signal Characteristics

An analog signal input to the ExPCA shall be current limited to 4 to 20 mA (TBC) dc via a 250 ohm $\pm$1% resistor.

9.3.3 Preconditioned Signal Characteristics

An analog signal input to the ExPCA shall (1) be a +5 Vdc (TBC) output signal. The dc input impedance shall (2) be greater than or equal to 1 megohm.

9.3.4 Analog Driver Characteristics

The electrical characteristics of the payload analog driver circuit (output from the payload) shall be compatible with the ExPCA receiver circuit illustrated in Figure 9-2.

9.4 DISCRETE COMMUNICATIONS

All discrete communications are via the ExPCA. The following paragraphs are written with the ExPCA as the reference (i.e., outputs are from the ExPCA, and inputs are to the ExPCA). Discretes are bi-directional and programmed at the ExPCA. The sampling rate of the payload data by the ExPCA will be 1 Hz. All discretes for a single position must be sampled at the same rate. Discrete output interfaces can operate as steady-state output or a pulsed output.

9.4.1 Discrete Signal Characteristics

The discrete output (from the ExPCA) signal is a single ended signal, and the discrete input (to the ExPCA) is a single ended signal.

9.4.1.1 +5V Discrete Input/Output Logic Low Level

The PD hardware shall be compatible with a digital “zero” level output of less than +1.0 Vdc (TBC) between input pins.

9.4.1.2 +5 V Discrete Input/Output Logic High Level

The PD hardware shall be compatible with a digital “one” level output of greater than +3.5 Vdc (TBC) between input pins.

TBD#9-01

FIGURE 9-2 INPUT AMPLIFIER FOR ANALOG SIGNALS TO BE DIGITIZED (EXPCA ANALOG RECEIVER CIRCUIT)

9.4.1.3 +28 V Discrete Input/Output Logic Low Level

The PD hardware shall be compatible with a digital “zero” level output of less than +5 Vdc (TBC) between input pins.

9.4.1.4 +28 V Discrete Input/Output Logic High Level

The PD hardware shall be compatible with a digital “one” level output of greater than +24 Vdc (TBC) between input pins.

9.4.1.5 Discrete Pulsed Outputs

Discrete outputs of 0 to +5 Vdc and 0 to +28 Vdc from the ExPCA can be operated in pulsed mode. If the ExP payload uses this mode, it shall be compatible with a pulsed output duration of 50 ms to 250 ms capable of 10 ms steps with an accuracy of $\pm$5 ms.

9.4.1.6 Discrete Output Maximum Fault Current

The PD hardware shall be compatible with and not be damaged by indefinite exposure to a misconnection to **TBD#9-02** Vdc source or sustained short. Output current under these conditions will be limited to **TBD#9-03** continuous and up to **TBD#9-04** for a duration of up to **TBD#9-05** sec.

9.4.1.7 Discrete Input Maximum Fault Voltage

The PD hardware shall not output any voltage outside the range of **TBD#9-06** Vdc indefinitely due to any fault condition.

9.4.2 Discrete Driver and Receiver Characteristics

The electrical characteristics of the payload discrete driver circuit shall (1) be compatible with the ExPCA receiver circuit illustrated in Figure 9-3. The electrical characteristics of the payload discrete receiver circuit shall (2) be compatible with the ExPCA driver circuit illustrated in Figure 9-3.

TBD#9-07

FIGURE 9-3 EXPCA DISCRETE RECEIVER CIRCUIT AND DRIVER CIRCUIT FOR DISCRETE COMMUNICATIONS

SECTION 10, ENVIRONMENTAL INTERFACES

This section defines the environments for which the ExP payload shall be compatible. This section contains only those environmental requirements which are not covered in the specific discipline sections (i.e., Electrical, Thermal, EMC/EMI, Structures, etc.). The environments defined in the following paragraphs should be considered design-to requirements and should provide a basis for any applicable analyses, tests, or inspections which must be conducted during the payload development process.

10.1 PAYLOAD EQUIPMENT SURFACE CLEANLINESS

A. Design shall allow external surfaces to be cleaned with solvents and equipment available at the launch site (lint free cloths/swabs, isopropyl alcohol, demineralized water etc.). Visibly clean "Standard" is the baseline level for all payloads.

B. Payloads shall be delivered clean (external and accessible surfaces) and protected to visibly clean "Standard" as prescribed in JSC SN-C-0005. Cleaning fluids will be per NSTS 08242.

10.2 EXTERNAL CONTAMINATION

It is a necessity to maintain a clean environment for payload operation and to minimize external contamination of the ISS and other payloads. Materials selection shall be implemented based on outgassing properties of the materials to keep external contamination due to molecular deposition below ISS system requirements levels as stated in SSP 30426. Venting from payloads must be controlled in order to meet both the molecular column density and molecular deposition requirements of SSP 30426.

10.2.1 Molecular Column Density From Venting, Leakage, and Outgassing

The contribution to the molecular column density created by an attached payload along any unobstructed line of sight shall not exceed 1×10^{14} molecules/cm^2 for any individual species, when viewed from any attached payload location. The molecular column density limit may be exceeded for lines of sight parallel to and within 1 m from the vehicle vent axis.

10.2.2 Molecular Deposition From Materials Outgassing and Venting

Nonmetallic materials that are used in quantities greater than 20 grams or 4 cm^2 or have a line of sight to sensitive surfaces on other payloads or ISS vehicle hardware and are exposed to space vacuum (which includes any internal materials within a non-pressurized shell as well as external materials) shall (1) be tested per ASTM-E1559. The test results shall (2) be documented and submitted to the integrator for use in an integrated system-level assessment. The materials data shall (3) include location, application, operating temperature, condensable outgassing rate (in g/cm^2 sec), test source temperature, test receiver temperature, total surface area, and percent of total payload surface area. This test may be performed on individual materials or at the component level. The combined molecular deposition from a given payload on a 300 K surface located anywhere on an adjacent payload envelope shall (4) not exceed **TBD#10-01** g/cm^2 sec.

10.2.3 Solid, Particulate, and Liquid Releases

Solid, particulate, and liquid releases shall not result in residual deposits as indicated in SSP 30426, Section 3.5.2, or damage to other ISS surfaces from either direct or indirect orbital impingement.

10.3 LASER REQUIREMENTS

Laser use shall be coordinated with EXPRESS EI to ensure compatible operations with ISS and adjacent payloads.

10.4 RADIATION REQUIREMENTS

Payloads are required to meet the radiation emission requirements specified in Section 7 of this IDD. Payloads on board the ISS are exposed to natural and induced radiation environments. The SSP 52000-PAH-EPP provides design guidelines and reference material addressing this subject.

10.4.1 Payload Contained or Generated Ionizing Radiation

Payloads containing or using radioactive materials or materials that generate ionizing radiation must be identified and submitted to the ExP integrator for approval.

Radioactive materials shall comply with appropriate license requirements at the planned launch and landing sites as well as the ISS Program.

10.4.2 Single Event Effect (SEE) Ionizing Radiation

Materials and equipment shall not produce an unsafe condition or one that could cause damage to the ISS, ExP, or other payloads as a result of ionizing radiation-produced SEE. SEE analysis shall be performed per SSP 30512.

Design Guidance: SEE is a generalized category of anomalies that result from a single ionizing particle. This term includes such effects as single event upsets, transients, latchup, permanent upset, and device burnout effects.

Design Guidance: To minimize the risk of improper operation of ExP payloads during periods of SEE, it is prudent to utilize system solutions which lessen the probability of SEE upset or ones that provide a method of recovery after an SEE is encountered. One such method, relevant to digital circuits, is implementation of Error Detection and Correction (EDAC) circuitry with Random Access Memory (RAM) program memory. EDAC circuitry automatically corrects single-bit errors and detects/flags double-bit errors of corrupted program memory instructions/data before Central Processing Unit (CPU) execution, thus eliminating the possibility of the CPU execution of an improper command and/or CPU "lock-up." EDAC can also be combined with "RAM scrubbing" to eliminate the possibility of double-bit errors before they occur by sampling and correcting memory contents in background with a programmable scrub rate (variable per SEE occurrences encountered). A recovery method for digital circuits employs a watch-dog timer circuit to monitor proper CPU operation and reset the CPU to a known state if a lock-up condition is encountered. Another area of concern in high power applications is the susceptibility of power field effect transistors to SEE. This problem can be circumvented by careful selection and screening of the part by the PD. These components can vary widely from component to component and manufacturer to manufacturer. One last precaution is given to the use of Electrically Erasable Programmable Read-Only Memory (EEPROM) in ExP payloads because of the potential susceptibility to SEE of these devices during write operations (only read operation use is recommended).

10.4.3 Total Dose Ionizing Radiation

Payloads shall not produce a condition that could cause damage to the ISS ExP or other payloads as a result of exposure to a radiation dose per the parameters of SSP 30512.

10.5 ATMOSPHERE REQUIREMENTS

10.5.1 Humidity

The ExP payload shall be designed to withstand relative humidity levels up to 100 percent during ground processing checkout operations.

10.5.2 Atomic Oxygen (AO)

A. The ExP payload shall withstand an AO fluence of 5.0×10^{21} atoms per cm^2 per year for the on-orbit exposure duration.

The AO environment is not applicable to payload internal surfaces and equipment, except when exposed to the external AO environment during ISS operations.

B. Surfaces exposed 30 days or less shall withstand 4.4 x 10^{19} atoms per cm^2 per day.

10.5.3 Plasma

The ExP payload shall be designed to withstand the on-orbit natural plasma environment as specified in SSP 30425, Section 5.0, and the induced plasma environment as specified in SSP 30420, Section 3.3. The difference between the attached payload structure floating potential and the local plasma potential does not exceed $\pm$40 V.

10.5.4 Solar Ultraviolet Radiation

The ExP payload shall be designed to withstand the on-orbit ultraviolet environment as specified in SSP 30425, paragraph 7.2.

10.5.5 Plume Impingement

ExP payloads and exposed secondary structure [e.g., Multilayer Insulation (MLI) blankets] shall withstand the maximum effective normal and shear plume impingement pressures defined below:

A. Normal pressure 3.42 psf

B. Shear pressure 0.80 psf

10.5.6 Micrometeoroid and Orbital Debris (M/OD)

ExP payloads that contain M/OD critical items as defined by SSP 52005, paragraph 5.1.5, shall meet the requirements specified herein when exposed to the M/OD environments as specified in SSP 30425, paragraph 8.0. Parameters of Space Station M/OD environments definition are given in Table 5.1.5-1 of SSP 52005. M/OD critical items include pressure vessels, cryogenics, batteries, etc.

Design Guidance: The parameters provided in Table 5.1.5-1 of SSP 52005 are to be input in the Bumper-II model for M/OD analysis. These are not design requirements and should not be interpreted as such, but are only the worst-case parameters to be input into the model. The Bumper -II computer model utilizes a statistical approach to determine the probability of penetration for various size particles striking a surface in orbit to determine if M/OD shielding is required.

SECTION 11, SOFTWARE COMMUNICATIONS

The software which interfaces to the payload is identified in the subsequent paragraphs. The ExPCA is intended to be primarily a “pass-through” for commands and data to and from the ExP payload. Therefore, the protocol defined in SSP 52050 also applies to ExP payloads as referenced in the following paragraphs.

11.1 EXP CONTROL ASSEMBLY SOFTWARE

Figure 11-1 depicts the ExPCA interfaces to the payloads. Table 11-I summarizes the ExPCA direct interfaces to the payload item. In this section, messages sent to the payload will be referred to as “commands,” and messages sent from the payload will be referred to as “requests.” Science and/or health and status information sent from the payload will be referred to as either “data” or “telemetry.” Figure 11-2 illustrates at a high level the end-to-end description of command flow for a command from the Payload Executive Processor (PEP) (such as ground and timeline command) to a payload ExP laptop. Figure 11-3 illustrates at a high level the end-to-end description of the request flows from a payload to the PEP. The following paragraph provides information on each interface for the payloads (MIL-STD-1553B, Ethernet).

11.1.1 ExPCA MIL-STD-1553 Bus Communications

The MIL-STD-1553B connections for which the payload shall (1) be compatible are MIL-STD-1553B, Digital Time Division Command/Response Multiplex Data Bus. The ExPCA interfaces to the PL MDM in accordance with MIL-STD-1553B for uplink of payload commands and downlink of Health and Status telemetry. The data and files elements for the payload MIL-STD-1553B interfaces with which the payload shall (2) comply are shown in Table 11-II.

The ExP payload should implement the MIL-STD-1553 bus as defined in the referenced standard and as tailored (for the command word, status word, and data word interface) in SSP 52050, 3.2.3.2.1, 3.2.3.2.2, and 3.2.3.2.3.

The ExP payload shall (3) utilize/respond to the subaddresses specified in SSP 52050, Table 3.2.3.2.1.4-1.

All command and message communications on this bus shall (4) include the Consultative Committee on Space Data Systems (CCSDS) primary and secondary headers as defined in SSP 52050, 3.1.3.1 and 3.1.3.2 and as amended in Appendix D of SSP 52050.

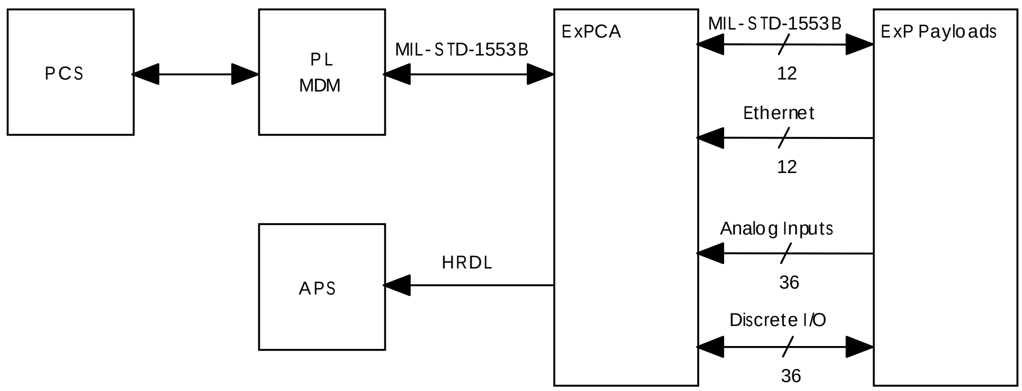

FIGURE 11-1 EXP INTERFACE DIAGRAM FOR EXPCA TO PAYLOADS

TABLE 11-I EXP PAYLOAD-RELATED EXPCA
INTERFACE IDENTIFICATION

NAME	DESCRIPTION	INTERFACE TYPE
MIL-STD-1553B	Status, service requests, health monitoring, ancillary data, file transfers, command and control	Software
Ethernet	High rate science data downlink	Software
Analog Inputs	Temperature, pressure, and preconditioned signal sensor inputs for status	Hardware
Discrete Inputs/Outputs	Control or status of payload systems	Hardware

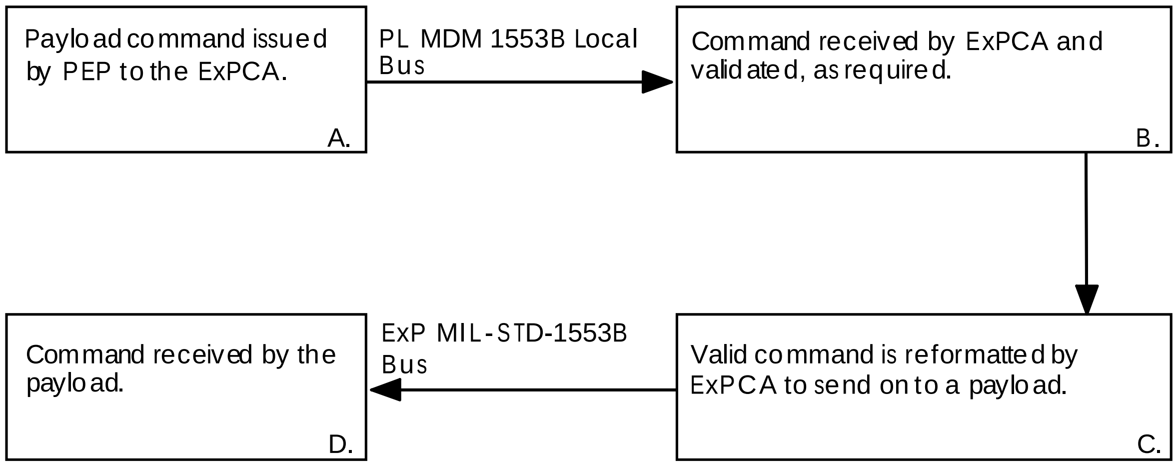

FIGURE 11-2 PAYLOAD PEP COMMAND

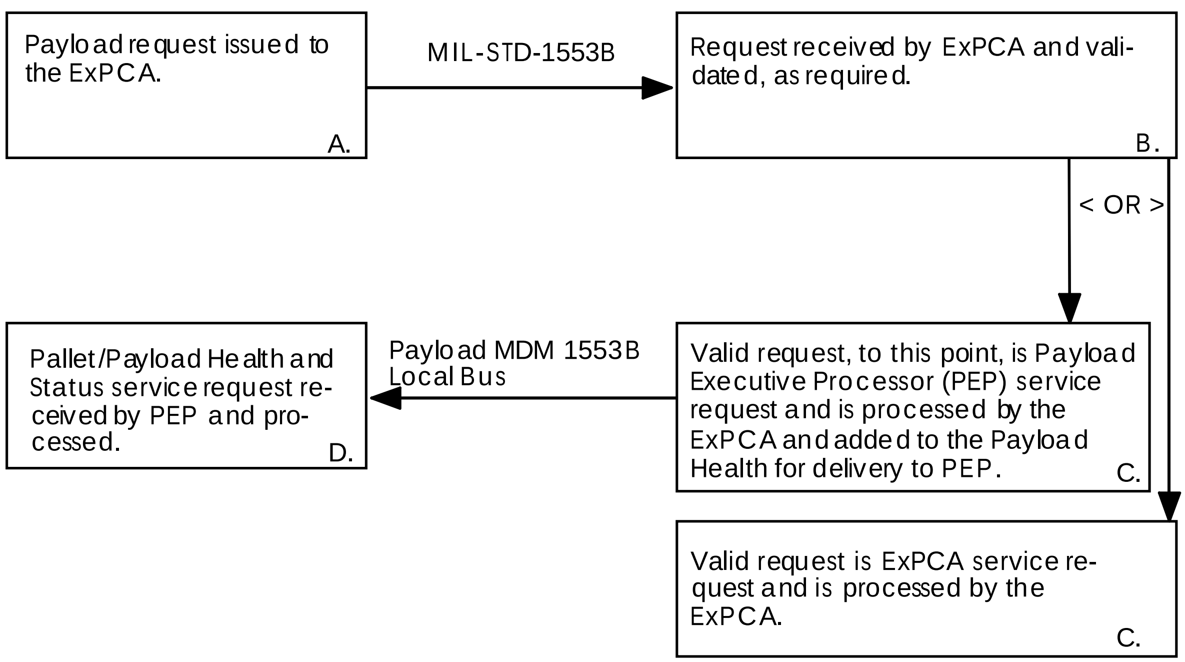

FIGURE 11-3 END-TO-END SERVICE REQUEST FOR PAYLOAD FLOW

TABLE 11-II PAYLOAD MIL-STD-1553B EXTERNAL INTERFACE DATA ELEMENT (8)

DESCRIPTION	SOURCE	DESTINA-TION	FREQUENCY	DATA FORMAT	PARA REFERENCE
MIL-STD-1553B Payload to ExPCA					
Service Requests	PLD	ExPCA	Async	MIL-STD-1553	11.1.1.9
Payload Health and Status	PLD	ExPCA	1 Hz	MIL-STD-1553	11.1.1.7
Low Rate Telemetry	PLD	ExPCA	Async	MIL-STD-1553	11.1.1.12
ExPCA to MIL-STD-1553B Payload					
Ancillary Data Set	ExPCA	PLD	Async, .1, 1 Hz	MIL-STD-1553	11.1.1.10
Broadcast Ancillary Data Packet	ExPCA	PLD	10 Hz	MIL-STD-1553	11.1.1.10
Request Response	ExPCA	PLD	Async	MIL-STD-1553	11.1.1.9
Broadcast Time	ExPCA	PLD	Async	MIL-STD-1553	11.1.1.6
File Loads	ExPCA	PLD	Async	MIL-STD-1553	11.1.1.11
Commands	ExPCA	PLD	Async	MIL-STD-1553	11.1.1.5

11.1.1.1 Receive Data Message

The ExP payload shall (1) recognize the Receive Data Message from the ExPCA as notification that data needs to be sent to the payload.

The ExP payload shall (2) respond with an appropriate status word as required by MIL-STD-1553B.

11.1.1.2 Transmit Data Message

The ExP payload shall (1) recognize the Transmit Data Message from the ExPCA as notification that data needs to be sent from the payload to the ExPCA.

The ExP payload shall (2) respond with an appropriate status word as required by MIL-STD-1553B and the payload data requested.

11.1.1.3 RT Assignment

The ExP payload RT addresses shall be contained in the ExP payload's Unique Payload Software ICD of the SSP 57002 series Software ICD Template.

11.1.1.4 Data Management of MIL-STD-1553 Commands and Messages

The ExPCA will support command processing, broadcast time, health and status message, service requests, service request responses, broadcast ancillary data, unique ancillary data transfer, file transfers, and low rate telemetry to ExP payloads over the ExPCA MIL-STD-1553 bus per SSP 52050.

11.1.1.5 Command Processing

ExP payloads shall (1) accept 64-word command packets from the ExPCA formatted per SSP 52050, Table 3.2.3.4-1 (with the checksum contained in the last word of the command (packet). The ExPCA will be capable of transmitting up to 10 command packets per second to ExP payloads.

ExP payloads shall (2) verify the intended destination of a command packet via the subset ID in word #8 of the CCSDS header of the command packet formatted per SSP 52050, Figure 3.1.3.1-1 as modified in Appendix D of SSP 52050 (PIRN-52000-NA-0003, January 18, 1999).

The ExP payload shall (3) also verify the checksum by computing a 16-bit add without carry checkword and comparing this with the checksum embedded in the last word of the command packet. The ExP payload shall (4) not execute any command which has failed APID or checksum validation.

11.1.1.6 Broadcast Time

ExP payloads shall receive the 32-word broadcast time message once per second per SSP 41175-2, 3.3.2.2.2.

11.1.1.7 Health and Status Packet Transfers

ExP payloads shall (1) transmit the health and status message as requested by the ExPCA in accordance with SSP 52050, paragraph 3.2.3.5. All health and status message parameters shall (2) be documented in the ExP payload's C&DH Data Set and the Unique Payload Software ICD of the SSP 57002 series Software ICD Template.

The ExP payload health and status message shall (3) include two 32-word packets of health and status data sent once per second formatted per Figure 11-4 and per SSP 52050, Table 3.2.3.5-1 (for message #1 and message #2 only).

64 Words Max	CCSDS Header (8 words)
	Subset ID (1 word)
	Service Request ID (1 word)
	Service Request Data (1 word)
	Caution and Warning Word (1 word)
	Health and Status Data (payload unique length) (52 words max)

FIGURE 11-4 EXP PAYLOAD HEALTH AND STATUS FORMAT

Note: Health and status packet allocation to an ExP payload may be available in one to four 32-word packets subject to the health and status requirements of the co-resident ExP payloads and to ExPCA application software design limitations.

11.1.1.8 Caution and Warning (C&W) and Safety Data

The ExP payload shall (1) include data designated as "Safety Data" in the health and status message per SSP 52050, 3.2.3.6. The specific safety parameters will be determined by the PD in conjunction with the PSRP and associated safety reviews. The C&W word in word 4 of the health and status data packet shall define the nature of the C&W event related to the embedded safety data parameters.

ExP payloads shall (2) include in health and status packets a payload-unique subset ID in word 9 as defined in SSP 57002, Table A-5.

11.1.1.9 Service Request

The ExPCA shall (1) support service requests from the ExP payload for data flow control of Unique Ancillary Data, File Data Loads, low rate telemetry, and timeliner execution requests for bundle handling and procedure executions. Detail discussion of service request processes is contained in the Payload User's Manual per CR 1783, SSP **TBD#11-01**. Service request IDs (defined in SSP 52050, Table 3.2.3.7-1) from ExP payloads shall (2) be embedded in the health and status packet per Figure 11-4. ISS service request responses sent to the ExP payload will be formatted per SSP 52050, Table 3.2.3.7-2. Service request response fault code values are defined in SSP 52050, Table 3.2.3.7-3.

11.1.1.10 Ancillary Data Packet

The ExP payload shall (1) receive the 64-word broadcast ancillary data message as defined in SSP 52050, paragraph 3.2.3.8.1. The ExPCA will be capable of transmitting broadcast ancillary data messages up to 10 times per second.

The ExP payload shall (2) receive the 32-word unique ancillary data message (preceded by the proper service request) as defined in SSP 52050, paragraph 3.2.3.8.1 and as defined in the ExP payload's Payload Ancillary Data Set and the Unique Payload Software ICD of the SSP 57002 series Software ICD Template. The ExPCA will be capable of transmitting unique ancillary data messages up to 10 times per second.

11.1.1.11 File Data Packet

The ExP payload shall (1) receive the file data packet (preceded by the proper service request) as defined in SSP 52050, Table 3.2.3.9-1.

File data transfers from the ExP payload (RT) to the ExPCA [Bus Controller (BC)] shall (2) not be permitted.

The ExP payload using the file transfer function shall (3) be capable of receiving nine 32-words file data packets every 100 ms until the file transfer is complete.

11.1.1.12 Low Rate Telemetry Packet

The ExP payload shall transmit the low rate telemetry packet (preceded by the proper service request) as defined in SSP 52050, paragraph 3.2.3.10. The ExPCA will be capable of receiving up to 640 words from 1 to 10 times per second from an ExP payload, although at each 640-word boundary this service may be reallocated to another payload based upon previously received service requests.

11.1.2 ExPCA Medium Rate Data Link (MRDL) LAN Communications (TBC)

The Ethernet connections for which the payload shall (1) be compatible are ISO/IEC 8802-3, Carrier Sense Multiple Access with Collision Detection Local Area Network Specification, Type 10BASE-T compliant.

The ExPCA will support MDRL telemetry transfers to ISS from ExP payloads over the ExPCA ISO/IEC 8802-3 interface.

The MRDL ISO/IEC 8802-3 protocol shall (2) be in accordance with SSP 52050, Section 3.3 (excluding paragraphs 3.3.2, 3.3.3.5, and 3.3.3.6). The ExP payload shall (3) not exceed a sustained data rate of 6 Mbps.

The ExP payload shall (4) include the primary and secondary CCSDS headers as defined in SSP 52050, 3.1.3.1 and 3.1.3.2 in all MRDL/ High Rate Data Link (HRDL) telemetry message packets to support decommutation of science data on the ground.

ExP payload shall (5) define their MRDL data per SSP 57002, Table A-10.

11.2 ISS PORTABLE LAPTOP COMPUTER SYSTEM

Reference SSP 52052-IDD-PCS for design requirements and information regarding the ISS Portable Computer System (PCS). Payloads planning to use the ISS PCS shall comply with the applicable requirements in SSP 52052-IDD-PCS and associated schedule templates. The PCS does not physically interface with the ExP or payloads.

11.3 SOFTWARE SAFETY REQUIREMENTS FOR PAYLOADS

All software shall be considered 0-fault tolerant in the design of the payload hardware.

11.4 HUNTSVILLE OPERATIONS SUPPORT CENTER (HOSC) DATA PROCESSING

Payloads planning to use the HOSC for ground data processing of their downlink low rate health and status and high rate science data shall meet the requirements of MSFC-STD-1274B, Volume 2.

SECTION 12, EXTRAVEHICULAR ROBOTIC (EVR) AND EXTRAVEHICULAR ACTIVITY (EVA)

For nominal operations, ExPA installation/deinstallation operations will be performed using EVR, with contingency EVA capability. This will be handled at the ExPA or ExP level. ExP payloads will not interface directly with the robotic systems. It is important to note that the ExP payload must remain in the payload dimensional envelope as defined in Section 3.6.1 during robotic operations.

EVA is not planned and will be performed only in case of EVR failure. There will be no direct crew interface to payload during EVA activity. It is important to note that strict adherence to the requirements defined in Section 3.6 must be maintained to prevent injury to crewmembers in the event of a contingency EVA.

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SECTION 13, MATERIALS AND PROCESSES INTERFACE REQUIREMENTS

13.1 MATERIALS AND PROCESSES USE AND SELECTION

Materials and processes used in the design and construction of ExP payloads which directly or functionally interface with the ISS/carrier and the orbiter carrier shall (1) comply with NSTS 1700.7, paragraphs 208.3 and 209 in their entirety, and NSTS 1700.7, ISS Addendum, paragraphs 208.3 and 209 in their entirety. Commercial/Off-The-Shelf (COTS) parts used in experiment hardware shall (2) meet these same materials requirements.

For those NASA centers which participate in the NASA Materials and Processes Intercenter Agreement for ISS payloads, the Intercenter Agreement baselines the process for selection and certification of materials used in payload hardware to the safety requirements of NSTS 1700.7 and NSTS 1700.7, ISS Addendum, paragraphs 208.3 and 209 in their entirety.

Whenever possible, materials should be selected that have already been shown to meet the applicable acceptance test criteria. Existing test data are compiled in the NASA Marshall Space Flight Center (MSFC) Materials and Processes Technical Information System (MAPTIS) electronic database. A hardcopy version of the MAPTIS database is published periodically as a joint document with Johnson Space Center (JSC), MSFC-HDBK-527/JSC 09694, “Materials Selection List for Space Hardware Systems.”

13.1.1 Acceptance Criteria for Stress Corrosion Cracking (SCC)

Metallic materials (especially those considered to be structure members, such as payload structures, support bracketry, and mounting hardware, and those whose failure could result in a critical or catastrophic hazard) which have a high resistance (A-rated) to SCC according to the criteria of MSFC-SPEC-522 shall be used.

13.1.2 Hazardous Materials and Compatibility

The use of materials, chemicals, and fluids which could create a toxic or hazardous situation for the crew, or which could contribute to the deterioration of hardware in service, shall be given special consideration as to adequate containment and compatibility.

13.1.3 Test and Acceptance Criteria for Flammability

Payload materials shall be nonflammable or self-extinguishing per the test criteria of NASA-STD-6001.

13.1.4 Test and Acceptance Criteria for Thermal Vacuum Stability (TVS)

All materials used in hardware which will be exposed to space vacuum shall have low outgassing characteristics as defined by a total mass loss of ≤ 1.0 percent and a volatile condensable material of ≤ 0.1 percent when tested per ASTM-E595, Standard Test Method of Total Mass Loss and Collected Volatile Materials from Outgassing in a Vacuum Environment.

13.2 MATERIALS AND PARTS CERTIFICATION AND TRACEABILITY

For fracture-critical parts, traceability documentation per NASA-STD-5003 shall be located at the PD site and be available for review upon request.

SECTION 14, VIEWING ENVIRONMENT

14.1 FOV INTRODUCTION

Many ExP payloads require an unobstructed viewing environment to achieve either the science, operations, or engineering objectives of the experiment. Payload Field-Of-View (FOV) requirements are usually defined in terms of conic or other geometric projections from the payload sensor, which is oriented at some azimuth, and elevation angle relative to the ISS reference coordinate system. Obstructions to the payload's FOV can be classified as near-field or far-field. Within these classifications, there are both fixed and moveable obstructions. Both the near-field and far-field FOV obstructions are described in the following paragraphs.

14.2 NEAR-FIELD FOV OBSTRUCTIONS

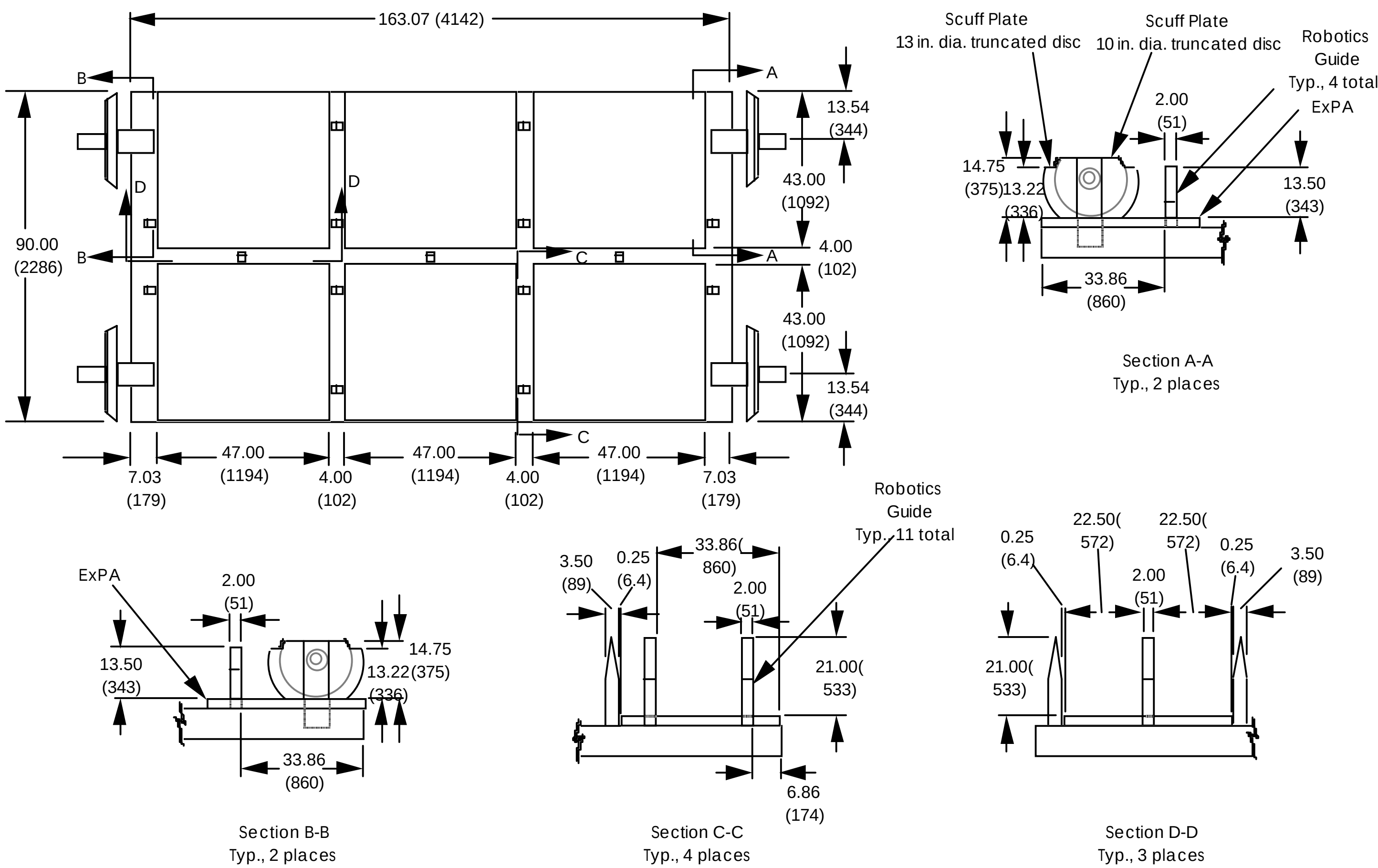
14.2.1 Near-Field Fixed FOV Obstructions

The near-field fixed obstructions for ExP-mounted payloads include structural hardware on the ExP such as the longeron trunnion scuff plates and the robotic guides which separate the ExPA payloads. Another major near-field obstruction is the adjacent ExP with payloads.

Near-field viewing obstructions for ExP payloads are shown in Figures 14-1, 14-2, and 14-3.

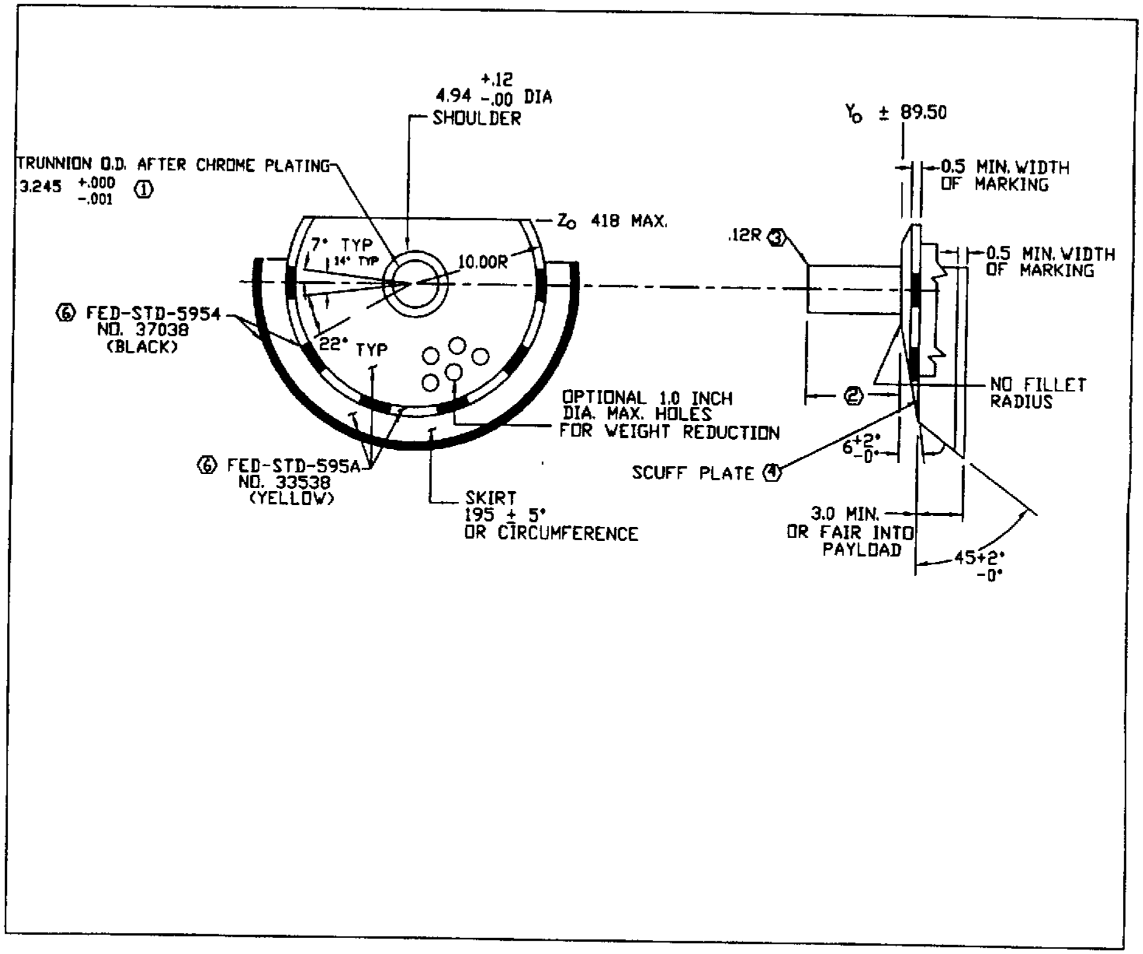
14.2.2 Near-Field Moveable FOV Obstructions

Near-field moveable FOV obstructions include moveable payload hardware on adjacent ExPAs and the adjacent ExP. They include robotic arms, antennas, or pointing and alignment devices on payloads. These FOV obstructions are unique to the payload complement for a given increment, and any exceedances to the ExP payload envelope will have to be approved by the ISS Program. Payload envelope exceedances will be preplanned operations, and neighboring ExP payloads will be informed about any permanent or intermittent payload envelope exceedances.



NOTES:
1. Dimensions: in (mm)
2. Typ. - Typical

FIGURE 14-1 EXP NEAR-FIELD FIXED VIEWING ENVIRONMENTS (TBC)



NOTES:

1. Dimensions in inches
2. Source: NSTS 21000-IDD-ISS

FIGURE 14-2 SCUFF PLATE DETAILS (Sheet 1 of 2)

NOTES:

1. TRUNNION SURFACE MATERIAL:

   ON NICKEL-BASED ALLOYS (e.g., INCONEL 718): ELECTRO-DEPOSITED CHROME (PER FEDERAL SPEC. QQ-C-320B, CLASS 2); THICKNESS 0.0003 IN. (0.008MM) MINIMUM.
   ON TITANIUM: ELECTRO-DEPOSITED CHROME (PER ROCKWELL SPEC MA0109-318); THICKNESS 0.002 IN. (0.05MM) MINIMUM. TRUNNION SURFACE FINISH AFTER CHROME PLATING 8√ (8 RHR, MEASURED IN MICROINCHES - EQUIVALENT TO 0.2 MICRON). SUBSEQUENT TO GRINDING, THE FINAL SURFACE FINISH SHALL BE OBTAINED BY POLISHING, LAPPING, BUFFING, OR SIMILAR METHODS.

2. TRUNNION LENGTH SHALL BE IN ACCORDANCE WITH THE FOLLOWING:
   FOR TRUNNION SPACING IN THE X_o DIRECTION OF 100 INCHES OR LESS -
   LENGTH IS 7.00 INCHES
   FOR TRUNNION SPACING GREATER THAN 100 INCHES -
   LENGTH IS 8.25 INCHES

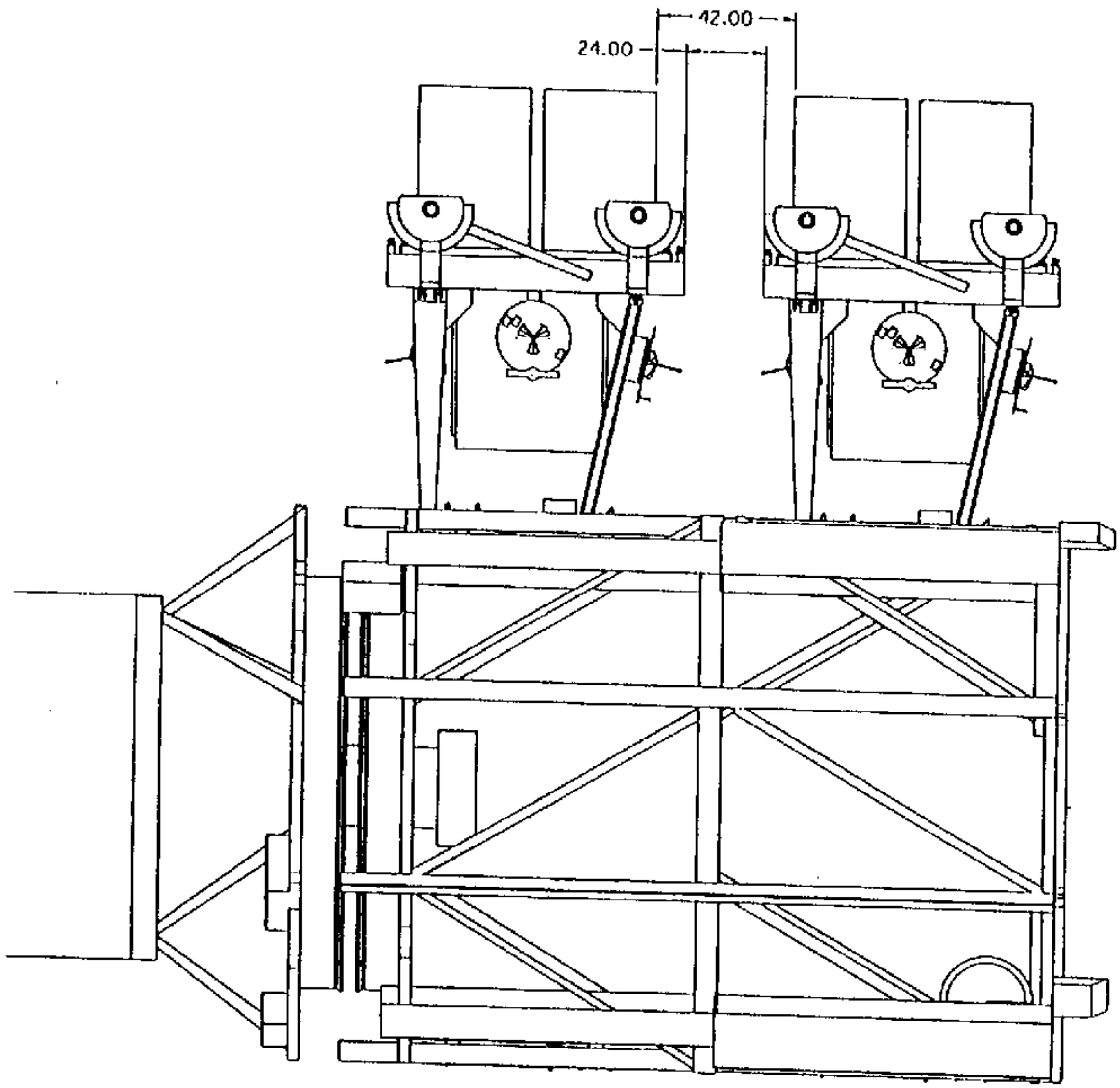
3. THIS RADIUS FAIRED WITH NO MISMATCH TO CYLINDRICAL SURFACE.

4. AT SUPPLIERS OPTION, SCUFF PLATE MAY BE SEPARATE PIECE ATTACHED TO TRUNNION OR MAY BE INTEGRAL PART OF TRUNNION OR PAYLOAD.

5 SCUFF PLATE IMPACT REQUIREMENT: ENERGY EQUIVALENT TO CARGO ELEMENT MASS MOVING AT 0.11 FPS (32K CARGO ELEMENT MAX).

6. THE BLACK AND YELLOW COLORS ARE NOT REQUIRED FOR ANY CARGO ELEMENT WHICH DOES NOT RETURN ON THE SAME MISSION IT WAS DEPLOYED ON.

FIGURE 14-2 SCUFF PLATE DETAILS (Sheet 2 of 2)



NOTES:

1. Dimensions in inches
2. Typical for both nadir and zenith sides of ITS

FIGURE 14-3 EXP SPACING ON ISS

14.3 FAR-FIELD FOV OBSTRUCTIONS

14.3.1 Far-Field Fixed FOV Obstructions

Far-field fixed obstructions include major ISS elements such as truss segments and pressurized modules. Simulated views from these ExP payload positions are included as an appendix to SSP 52000-PAH-EPP. These views include FOV obstructions that can be attributed to fixed, far-field ISS hardware.

14.3.2 Far-Field Moveable FOV Obstructions

Far-field ISS moveable obstructions include the following:

A. Photovoltaic arrays

B. Radiators

C. Mobile Transporter (MT)

D. Special Purpose Dexterous Manipulator (SPDM)

E. Space Station Remote Manipulator System (SSRMS)

F. Space Shuttle Orbiter

G. Progress vehicles

H. Other vehicles

Many of these far-field moveable obstructions are intermittent and occur during periods of vehicle dockings and hardware transfer on ISS. Therefore, these obstructions generally occur during periods that are not considered as optimal for science observations by attached payloads.

Simulated views from ExP payload positions are included as an appendix to SSP 52000-PAH-EPP. Included in these views are obstructions that can be attributed to some of the moveable far-field ISS hardware and vehicles.

SECTION 15, POINTING/ATTITUDE

Many ExP payloads require precise and stable pointing and alignment to achieve their science and engineering objectives. Pointing and alignment can be provided by either the carrier/vehicle or the payload or a combination of both. In the case of ExP on ISS, pointing and alignment is a payload-provided resource. The ExP does not provide pointing and alignment; ExP is fixed on the ISS truss. ExP payloads will provide their own pointing and alignment systems while meeting all the payload interface requirements specified for ExPA-mounted hardware. The ISS does not provide pointing and alignment for truss-mounted payloads; however, there are several attitudes the ISS will be flown in that will affect the ExP payload pointing and alignment processes. The ISS flight attitudes and attitude variations are defined in Section 3.2.5, Table XXI of S683-29523, United States Laboratory Specification.

The ExP payloads can obtain near real-time information regarding ISS attitudes from the ISS C&DH subsystem. ISS Guidance, Navigation, and Control (GN&C) parameters are part of the Broadcast Ancillary Data (BAD) set. These parameters are defined in SSP 41175-02, Software ICD, Part 1, Station Management and Control to ISS Book 2, General Interface Software Interfaces Requirements. Also, Global Positioning System (GPS) ISS parameters are defined in SSP 41177-05, Software ICD Part 1, GN&C-to-ISS Book 5, GPS Interface.

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